BOTANY

Volume LXXXIV Number 3

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NOVEMBER 1927

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Volume LXXXIV Number 3

THE BOTANICAL GAZETTE

A JOURNAL EMBRACING ALL DEPARTMENTS OF BOTANICAL SCIENCE

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Issued November 24, 1927

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October and November 1927

A New Old Testament

As advance accounts in the newspapers some time ago intimated, J. M. Powis Smith of the University of Chicago, Theophile J. Meek of the University of Toronto, Alex. R. Gordon of the United Theological College and McGill University, and Leroy Waterman of the University of Michigan, have completed their American Translation of the Old Testament. The excitement that the new version has caused in the daily press recalls that brought forth by the appearance of the Goodspeed translation of the New Testament four years ago.

While controversy rages the translators let the matter rest as stated in their Preface to the translation:

"Why should anyone make a new English version of the Old Testament? With the Authorized Version of King James and the British and American revisions, to say nothing of unofficial renderings, have we not enough? This question may quite fairly be asked. The only possible basis for a satisfactory answer must be either in a better knowledge of Hebrew, or in a fuller appreciation of fundamental textual problems, or in a clearer recognition of poetic structures, or in such a change in our own language as would render the language of the older translations more or less unintelligible to the average man of our day. As a matter of fact, our answer must be found in all of these.

"The most urgent demand for a new translation comes from the field of Hebrew scholarship. The control of Hebrew vocabulary and syntax available to the scholar of today is vastly greater than that at the command of the translators of the Authorized Version, or of its revisers.

"Modern studies of textual problems reinforce the need for a new rendering. . . . . The science of textual criticism has made great progress in recent years, and no translation of the Old Testament can afford to ignore its results. Our guiding principle has been that the official Massoretic text must be adhered to as long as it made satisfactory sense. . . . .

"Much of the text that has long passed as prose is now recognized as really poetic both in form and spirit. This adds to the necessity for a new translation. Poetry should not be printed as prose. The present translation brings into clear light many of the hidden beauties of Hebrew poetry. . . . .

"The English of King James's day is not wholly natural or clear to the average man of the present day. . . . . The use of 'vinegar' in the sense of a wine or liquor for drinking has long since ceased to be recognized. . . . . Facts like these make the reading of the Bible a scholarly rather than a religious exercise, and clearly point to the need for a new translation. . . . .

"The content of the Old Testament is, with little exception, on a high literary plane. The language of the translation, therefore, cannot be allowed to fall to the level of the street. In this translation the foregoing principles have been kept clearly in mind. It tries to be American in the sense that the writings of Lincoln, Roosevelt, and Wilson are American . . . . it aims at being easily understood wherever English is spoken. . . . .

"The translators and the University of Chicago Press have sought to give this translation the appearance of a modern book. This purpose has determined the make-up of the page and has led to the addition of headings for paragraphs, and to the *insertion of half-titles before* individual books. It has also kept verse numbers out of the text and relegated them to the margin. . . . ."

In the best tradition of modern English writing this new version interprets the impressive, eloquent Hebrew of centuries ago.

The following passage from "The Song of Songs, Which Is Solomon's" is illustrative of those sections which the translators have cast into poetic form:

THE MAIDEN TO THE YOUTH

Kiss me with kisses from your mouth,
for your love is better than wine;
the fragrance of your ointments is sweet;
Your very self is a precious ointment;
therefore do the maidens love you.
Take me along with you, let us hasten;
bring me, O king, into your chamber,
That we may exult and rejoice in you,
that we may praise your love more than wine;
rightly are you loved.

And here is a part of the story of Ruth in the new translation:

RUTH'S APPEAL TO BOAZ

Then her mother-in-law Naomi said to her,

"Should I not be seeking a home for you, my daughter, where you may be comfortable? Now then, what about our relative Boaz, with whose women you have been? See, he is going to winnow barley at the threshing-floor tonight. Wash and anoint yourself therefore, put on your best clothes, and go down to the threshing-floor; but do not let your presence be known to the man until he has finished eating and drinking. See to it, however, when he lies down, that you note the place where he lies; then go in, uncover his feet, and lie down yourself; he will let you know what to do."

"I will do just as you say," she responded.

So she went down to the threshing-floor, and did just as her mother-in-law had instructed her. When Boaz had eaten and drunk, and felt content, he went to lie down at the end of the grain-heap. Then she came in stealthily, uncovered his feet, and lay down. At midnight the man started up, and turning over, discovered a woman lying at his feet!

"Who are you?" he said.

"I am Ruth, your maidservant," she said. "Take your maidservant in marriage; for you are a near relative."

"May the Lord bless you, my girl!" he said. "This last kindness of yours is lovelier than the first, in that you have not run after the young men, either poor or rich. And now, my girl, have no fear; I will do all that you ask; for all the counselors of my people know that you are a fine woman. . . . ."

THE OLD TESTAMENT: AN AMERICAN TRANSLATION. Edited by J. M. Powis Smith. *Cloth $7.50, leather $10.00, postage 25 cents extra.*

Silly? Crazy? Damnable Heresy?

Since the appearance of his *Jesus: A New Biography*, Shirley Jackson Case has been heralded from the Atlantic to the Pacific by newspaper reporters as the arch-heretic of the century. Dr. Case, in attempting to show the modern reader "not the Jesus of the stained-glass window, but the Jesus who lived and walked with men," has, it seems, done something exceedingly sensational. The feeling of the publishers about the matter, however, has been expressed by the Nashville *Presbyterian Advance*, a by no means radical magazine, better than they could do it themselves:

"It appears that Professor Shirley Case, who has published several excellent volumes, has written a book on the life of Jesus. It is not yet published. [It has since appeared.] Some newspaper writer, however, learned something about the book and wrote a sensational story affirming that in the new book Dr. Case declares that Jesus did not affirm his own divinity. Whether this is a fact or not remains to be seen, but on the basis of the assertion of the 'exclusive story' (unfortunately the word 'exclusive' in such cases has come to have about the meaning of 'lying' to discriminating readers) other reporters got busy and interviewed some ministers. These ministers, without having seen the book, promptly proceeded to call it 'crazy' and 'silly' and at least two of them are quoted as calling it 'damnable heresy.' If there is

anything 'crazy' or 'silly' about the whole business, it is to be found in those persons who so violently denounce what they know absolutely nothing about, except on the 'say-so' of some untrained reporter who is probably unable to distinguish between theological dogmas and historical facts."

Hasty and popular as they are, entirely oblivious to the unique methods of scholarship upon which Dr. Case's biography rests, the newspaper accounts have nevertheless shown one significant thing: that the public is intensely interested in new interpretations of Jesus' life and work. The modern reader is eager to look back over the intervening centuries to Jesus as he actually was.

Professor Case has long been known as a scholar who has studied, more fruitfully, perhaps, than any other, the social background of early Christianity. His method has been his most original contribution. It has enabled him to bring the reader of today into direct contact with the environment of beginning Christianity. It enabled him to dispel in his *Historicity of Jesus* the recurring hoaxes that treat Jesus' existence as a myth. And it has now made it possible for him to bring the reader closer than ever before to the real Jesus of history, as he appeared to the men of his own time in Palestine over 1900 years ago.

Within the past few years there have been many unhistorical and sentimental lives of Jesus, but there has not been a biography dealing in so thoroughgoing a fashion with the results of scientific investigation.

JESUS: A NEW BIOGRAPHY. By Shirley Jackson Case. *$3.00, postpaid $3.15.*

* * *

The Ten Princes

Somewhere beyond the Himalaya Mountains lies Magadha, a land notorious for its unscrupulous delight in sensuous beauty and its ribald worldly wisdom. From this country, at a time when its people were gay, in love with poetry and pleasure, and shamelessly given to lying, fared Rajavahana and nine companion princes to conquer the four quarters of the universe. Dandin told the story of their adventures over a thousand years ago in *The Ten Princes*, his only prose novel. Arthur W. Ryder has retold it in a translation which retains the beauty of the original and adds a modern piquancy.

It seems that Rajavahana disappeared, and the nine companion princes, scattering to find him, met with a series of gay adventures in the course of which each gained a throne and an incredibly beautiful lady. Mr. Ryder's translation is a racy re-telling of Dandin's record, first of Rajavahana's experiences, and, as the other princes rejoin him, of their own exploits, related by them with appropriate flourishes and due exaggeration.

In these adventurers runs a pronounced strain of the picaresque. But rascals as they undoubtedly are, they must nevertheless be accredited with pleasant accomplishments. Handsome as no other mortals, erudite in ethics, astronomy, and metaphysics, they have a gift for the lute, are masters of magic, excel in horsemanship, and possess a scientific skill in thievery, gambling, and the arts of deception in general.

In their travels, they meet many beautiful maidens (versed in the arts of flirtation both major and minor), whom they charm by artifice and natural endowment, and describe in warm detail. And through their stories troop as great a crowd of shady characters, curious villains, and examples of shining virtues, as ever emerged from an oriental fancy: Buddhist nuns, unfaithful wives, sages, rakes, and kings, gay girls and gods, court ladies, merchants, thieves. Each has his appropriate philosophy which the princes remember to the last degree of subtlety, and readily report, whether the subject be the conduct of courtesans or the rules of political science.

Dandin was the master of a beautiful prose

style which has not lost in the translating. One feature of his art is sententious brevity. He looked upon prose as a more exacting medium than poetry itself. Of his life we know little more than that he flourished in India in the seventh Christian century. *THE TEN PRINCES*. Translated by ARTHUR W. RYDER. *$2.00, postpaid $2.10.*

Arthur W. Ryder has also translated from the Sanskrit *The Panchatantra* and *Gold's Gloom*. Achmed Abdulla says of *The Panchatantra:* "Fairytales. But Fairytales for grown-ups. Fairytales suffused with a wisdom that is ironic, slightly bitter, wire-drawn, perfectly civilized. Mr. Ryder's translation is most excellent. It shows not only a thorough knowledge of the subject but understanding, sympathy, style, and a keen sense of humor."

Gold's Gloom is bound in exceptionally attractive form, with bright-hued covers, and a specially designed title-page and headbands by Preissig. The quintessence of the wisdom and charm of *The Panchatantra*, it is a representative selection of some of the most captivating stories in the world. *THE PANCHATANTRA. $4.00, postpaid $4.15. GOLD'S GLOOM: TALES FROM THE PANCHATANTRA. $2.00, postpaid $2.10.* Translated from the Sanskrit by ARTHUR W. RYDER.

The World and Man

Critics unite in calling *The Nature of the World and of Man*, by Sixteen Ranking Scientists of the University of Chicago, one of the finest and most engrossing popularizations of current science in existence. A handsome new edition, with bright-hued covers, has just appeared. In accordance with its authors' wish that it should always represent the most recent knowledge of science, revisions have been made throughout the book.

Forest Ray Moulton, the astronomer, says of the volume's theme: "The Nature of the World and of Man is not only a great subject—in fact, the greatest one that human beings may investigate—but it is one rich in romance and filled with stirring adventure. It will satisfy, if anything can, the love of youth for heroic things. The giants of mythological days are far surpassed by the huge machines that are the untiring slaves of modern men. The eye of the fabled Cyclops was not even prophetic of the great telescope on Mount Wilson, the pupil of whose eye, so to speak, is 100 inches in diameter. Not all the magic of antiquity can match the marvels of any chemical laboratory. Physicians cast out demons by means of surgery, by the use of extracts of ductless glands, and by prescribing chemical compounds, and if they have not raised the dead even in a single instance, they have at least within a few decades increased the average span of human life by ten or fifteen years. . . . . In fact, reason and the laws of nature (mark well *reason* and the *laws of nature*) have become a sort of intellectual telescope, as it were, with which modern science looks back across the geological ages. . . . ." *THE NATURE OF THE WORLD AND OF MAN*. By SIXTEEN RANKING SCIENTISTS OF THE UNIVERSITY OF CHICAGO. *$5.00, postpaid $5.15.* (*Textbook Edition $4.00, postpaid $4.15.*)

More Contemporary Americans

In his second series of appraisals of American life and letters, Mr. Boynton gives the reader an unusual view of public taste in America, a view marked by absence of ridicule and obloquy, in short, a glimpse of what American culture has to show on the positive side. The design of the book centers around the theme that certain fine inherited traditions are surviving, that the public is not oblivious to them, and that a new public is developing with a taste distinctly its own.

Beginning with Melville, Bierce, and Hearn, men who wrote before their time and who belong in spirit to the present

day, Mr. Boynton proceeds to Hergesheimer, Anderson, and Lewis. Believing that it is as necessary for the critic to see and declare what the artist is trying to express as for him to discuss the mode of expression, he conducts the reader to the very center of each artist's own particular world.

Various aspects of the American scene from Paul Whiteman and the movies to the college insurgents appear in a lively discussion that ranges freely over the seven arts and over the traditions and innovations of American life. *MORE CONTEMPORARY AMERICANS.* By Percy Holmes Boynton. *$2.50, postpaid $2.60.*

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Sandburg, Dreiser, Mencken, Robinson, Frost, Lowell, Wharton, Tarkington, Cabell, Cather, O'Neill, and Bradford appear in this brilliant and engaging series of estimates of contemporary American literature. *SOME CONTEMPORARY AMERICANS.* By Percy Holmes Boynton. *$2.00, postpaid $2.10.*

Chinese Painting

An extraordinarily beautiful volume with fifty-seven plates in collotype is *Chinese Painting* by John C. Ferguson. Chinese art as it really is and as it is valued by the country that fostered it is written into this book with authority and understanding.

Mr. Ferguson's qualifications for judging the art of China by Chinese standards—as it must be done—are many. For thirty-five years he has lived in China in close association with all the connoisseurs and critics of his day, who have been his guides in the examination of extant specimens of writing and painting.

Beginning with the earliest records of China, Mr. Ferguson has written the history of painting in that country to the eighteenth century. The introductory paragraph is characteristic of the spirit of the book:

"More than three hundred years ago Chang Ch'ou wrote in the Preface to his *Ch'ing-ho Shu Hua Fang* that he would like to be transferred into a bookworm, and promised that he would not injure any of the manuscripts or paintings in which he lived, but would be contented with mere existence in their company. Such was the delight with which one of the ablest critics of Chinese writings and paintings reveled in his enormous task of separating the good from the bad, the genuine from the false, among the accumulated ink-remains of previous generations. If Chang Ch'ou could have had his wish gratified by becoming a bookworm, he would not have been of that variety which Emerson placed in contrast with 'Man Thinking,' for he had a keen mind. His wish was the measure of his appreciation of the worthy writings and paintings that came under his observation. These were the products of man's soul and were quite unlike the work of man's hands in bronze or clay or jade. Through these writings and paintings Chang Ch'ou held communion with the spirits of the great artists and calligraphists who preceded him, and in their unseen world there were no limits of time or space." *CHINESE PAINTING.* By John C. Ferguson. *Boxed, $12.50, postpaid $12.75.*

Roosevelt

Turning aside from the hero-worship which has in the past been an almost unavoidable snare to biographers, however desirous of presenting Roosevelt as he actually was, Howard C. Hill has written a book which even at this late date shows Roosevelt in a new light.

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The source material to which Mr. Hill has had access is more extensive than Roosevelt's biographers and historians have hitherto found available. Of this material, the most important part is the Roosevelt papers of the Library of Congress, to which only two or three others besides Mr. Hill have ever been given access. Although perhaps a quarter of his notes were censored by the official in charge, his book still includes the greatest amount of material that has ever been taken from this source.

Roosevelt the man, the creator of the Roosevelt myth, Mr. Hill would place before Roosevelt the statesman. Representative of Mr. Hill's view of Roosevelt in his official capacity is the following: "Rooseveltian imperialism as manifested in the Caribbean was opportunist in character, not planned or predetermined. Like the conscript fathers of ancient Rome, Roosevelt was led from one action to another by the swift current of events which during his administration seemed to change with kaleidoscopic rapidity. . . . . With each problem he dealt in the manner of a practical man of affairs rather than in the fashion of the doctrinaire or the man of predetermined policies."

The Boston Transcript comments, "We have Professor Hill to thank for a most interesting glimpse of our ex-President. . . . . He does not hammer away at his conclusions; he presents them gently. . . . . He invites us to strike a compromise, and therefore proves himself a most gracious gentleman, quite unlike any of his kind in the past or present. In his book we find for the student, an essay; for the interested reader, a narrative; for everyone, a striking portrait penned upon a background of living detail."

Harry Hansen in the *New York World* calls Mr. Hill's book "the sober second thought of the historian . . . . a very able study." And the *Herald-Tribune* says, "Professor Hill has turned the X-ray of historical criticism upon Roosevelt's Caribbean policy." *ROOSEVELT AND THE CARIBBEAN*. By HOWARD C. HILL. *$2.50, postpaid $2.60.*

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THE
BOTANICAL GAZETTE

November 1927

GERMINATION AND EARLY GROWTH OF CORNUS FLORIDA, SAMBUCUS CANADENSIS, AND BERBERIS THUNBERGII

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 374

OPAL HART DAVIS

(WITH FIVE FIGURES)

Introduction

The causes of delayed germination as summed up by CROCKER (7) fall into two groups: (1) those based on embryo characters, and (2) those based on coat characters. The seeds used in the present study all appear to be associated with the first group of causes.

The embryos are in no case immature, as found by IVES (21) in the holly. The seeds of *Cornus florida* seem rather to belong to a category of seeds, of which examples have been studied by DAVIS and ROSE (10) and ECKERSON (12) in *Crataegus mollis*, by HARRINGTON and HITE (20) in the apple, by PACK (33) in *Juniperus*, and by JONES (23) in the sugar maple. In every case a low percentage of germination is reported for untreated seeds, especially with testas removed, while cold treatment over a long period was necessary to overcome dormancy, and bring about a high percentage of germination. These workers found a temperature of 4° or 5° C. optimum for the process of after-ripening. They have reviewed most of the literature bearing on this type of delay.

Seeds of *Sambucus canadensis* and *Berberis thunbergii* seem to belong to a group sensitive to alternation of temperatures. HAR-

RINGTON (19) has given a comprehensive summary of the literature on this group, and has stated the theories in regard to the effect of temperature alternations on germination. MORINAGA (30) also has reported work with several seeds favored by alternation, including *Berberis thunbergii*.

The present investigation was undertaken to learn as much as possible about the factors related to the germination and early growth of *Cornus florida*, and to extend the work of ROSE (38) on *Sambucus canadensis* and of MORINAGA (30) on *Berberis thunbergii*.

Cornus florida

Cornus florida has a range through southern Maine, southern Ontario, southern Michigan, to Missouri, south to Florida, and west to Texas. It is found associated with all beech-sugar maple woods, and often with white or with white and black oak (the mesophytic oak forest). It is quite sun tolerant, as shown by its ability to grow in the open when transplanted, and by its frequent occurrence associated with hazel, sumac, bayberry, cherry, and sassafras, in semi-xerophytic thickets.

The flower buds form in late summer, and the embryo sac passes the winter in the 8-nucleate stage. MORSE (31) states that in 1906 the pollen shedding began May 14, and that in 1907, although the season was later, the shedding period was practically complete by May 27. He did not observe fertilization, but he noted that flower clusters in which there were no fertilized flowers were soon shed, and that large numbers of such heads could be seen under a single tree. The number of fertilized flowers to a head ranged from one to three. The present writer found as high as eight berries to the head in New York, where the trees are unusually plentiful. MORSE does not state whether unfertilized flowers in such heads developed to berries or not.

A large percentage of empty pericarps (100 per cent in seeds collected from solitary trees) was present in collections made in the woods of east central Indiana in 1923. These seeds showed no indications of attacks by fungi or insects, but were large, well formed fruits containing chambers slightly constricted, and one or more diminutive mummified kernels. The only situation giving seeds of

as much as 80–90 per cent seed content was that of a small group of trees on the north side of a dune, about one-fourth of a mile from Lake Michigan, between it and Long Lake, Indiana. Several other trees on the dunes, sometimes in groups of two or three and sometimes as individuals, showed the ravages of squirrels and birds, which are quite fond of the fruits. The seeds which were on the ground had nearly all been gnawed. Those still on the trees gave 15–20 per cent seed content.

During 1924–25 collections of *Cornus florida* seeds were made in a region noted for the abundance of these trees. During October more than a bushel of fruit was collected from trees on the hillsides east of the Hudson River, around Yonkers, New York. In only one case did the number of empty seeds reach more than 6–10 per cent. The trees often occur in clumps, but the seeds of those rather widely separated were good except in the one case, where the chambers up to 50 per cent were filled with soft milky kernels. The reason for such poor seeds has not been determined; in some cases it may be due to failure of fertilization, and in others to lack of nutrition.

By November 3 the squirrels and birds had cleared the fruit from most of the trees on the golf links and estates, and very few of the seeds could be found under the trees; however, in places less favorable for squirrels a great many of the seeds lay on the ground throughout the winter. It is evident that the attractiveness of their fruits and seeds to birds, and especially to squirrels and other rodents, and the tendency to produce hollow seeds where the trees are isolated, are limiting factors in the spread of *Cornus florida*. The chief determining factors, however, are probably related to the early dormancy of the seed.

PRELIMINARY STUDY.—During 1923–24, three lots of seeds were used in germination studies. The first was collected at Long Lake, Indiana, on October 8. These seeds were allowed to dry in the fleshy berry and were then stored at room temperature. The second lot was collected at Johns Hopkins University during October, and the seeds were dried and stored at room temperature, after the fleshy part had been washed entirely away. The third lot was secured from CONYERS B. FLEU at Philadelphia, February 27. These

had been collected from the trees in October, and stored in the berry at 30° F. from that time until they were sent.

For 1924–25, seeds were collected at Yonkers, New York, during October, and from one tree December 24. Five pounds of seeds which had been stored air-dry in the pulp, and one-fourth pound which had been stored moist in the berry at 50° C. until February 28 were obtained from CONYERS B. FLEU.

The seeds of the various lots differed very little from one another in size, color, or other points. The fruit of *Cornus florida* is an elliptical drupe, scarlet in color, the fleshy part of which somewhat resembles the red haw in texture. The flowers are epigynous, the sepals remaining on the apex of the fruit. The stone consists of a hard woody layer; an inner coat loose from the seed (and usually partially adhering to the woody layer, so that it is never left intact when the stones are broken); a grayish, flaky membrane of cells crushed together; the outer layer of the endosperm (a single layer of thick-walled cells); the endosperm; and the embryo lying exactly at its center and extending the full length of the seed (fig. 1). The second layer resembles quite closely the red testa of the peanut, being golden brown in color without, and gray within.

The outer layer of the endosperm forms a tough whitish membrane, which expands as the cotyledons grow and the stored material of the endosperm is used. If the seedling is kept in a moist atmosphere this coat slips off the cotyledons when they pull erect from the seed, or as they reach a size of 0.5×1 cm. If it remains on the cotyledons long enough to dry, however, they show some difficulty in escaping from it. It is very gradually split along the edges, and the cotyledons separate, with the membrane still clinging to them.

The embryo consists of the two cotyledons as broad as the seed (2.5–3 mm.) and about 4 mm. long, and a hypocotyl which from later development seems to be of two parts, a 0.5 mm. area forming the root and a 2 mm. region elongating and greening to form the stem. A rounded mass of meristematic tissue indicates the place of origin of the plumule. MORSE (31) found the young embryo well differentiated into cotyledons, hypocotyl, root tip, root cap, and embryonic tissues as early as July 28. Cross-sections of seeds col-

lected in October show the cotyledons to be differentiated into upper epidermis, two rows of palisades, parenchyma, and lower epidermis, with rounded clusters of undifferentiated vascular tissue. The

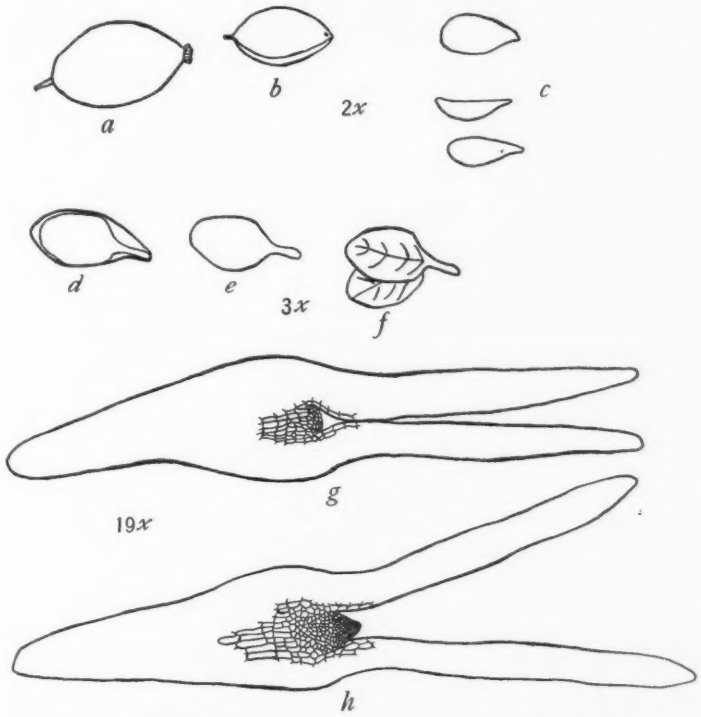

FIG. 1.—Fruit, seed, and embryo of *Cornus florida: a*, fruit; *c*, seed with stony covering removed; *b*, stone; *d*, *e*, *f*, embryo; *g*, plumule of air-dry seed; *h*, plumule of germinating seed.

hypocotyl portion shows elongated cells in the protostelar region, which differentiate into xylem and phloem immediately on the elongation of the hypocotyl.

Preliminary tests of hygroscopic moisture showed that the air-dry seeds range from 2.8 to 6 per cent. The reduction of the moisture content to this rather low amount had no effect on later germination, perhaps because the seeds are of the fat-protein type, having a

ipoid content of 48 per cent. Neither the bony covering nor testa immediately beneath it plays any part in causing the delay, except in so far as they act as a mechanical restraint to feebly swelling seeds. The water intake of seeds in the pericarp in distilled water reached as much as 61 per cent in three days, while that of seeds taken from the coats reached 50.5 per cent in twelve hours, at which time disintegration became sufficiently marked to interfere with the results. Large numbers of seeds freed from the pericarp and testa, and subjected to low temperatures for varying periods required the same length of treatment for inducing germination as those seeds tested with pericarps intact. Treatments with ether and ethylene were unsuccessful, as were also those in which an atmosphere high in O_2 was used.

For sterilizing the seeds used in these preliminary tests, Javel water was used with moderate success. It was made according to directions by MOLISCH (**29**) and diluted to 10 or 20 per cent. The 10 per cent was found the more satisfactory for disinfecting the seeds of *Cornus florida*. The seeds were sterilized with this solution according to the discontinuous method of DUGGAR and DAVIS (**11**).

METHODS

For germination studies during 1924–25, seeds were washed free from the pulp, sterilized for one-half hour in 0.25 per cent uspulun,[1] washed carefully with boiled tap water, and put under germinative conditions. To remove the pulp the seeds were run through an ordinary food chopper with the small cutting knife removed. The stones were then washed entirely free from pulpy material, sometimes by the aid of quartz sand rubbed with them in a canvas bag. All empty seeds floated and were eliminated.

Seeds thus prepared were placed under the conditions indicated in tables I to V. Large enough quantities (5000–10,000 seeds) were put under each germinative condition to permit physiological and chemical studies during the process of after-ripening and the early stages of germination. Seeds of this lot stored air-dry and a five pound lot of seeds stored dry in the pulp were also used for germination and other studies.

[1] Uspulun is a seed disinfectant containing hydroxymercurichlorophenol sulphate prepared by the Bayer Company.

Catalase activity was determined at intervals of ten to fourteen days during the period of after-ripening. The method has been described by APPLEMAN (**2**), CROCKER and HARRINGTON (**8**), RHINE (**37**), and several other workers.

Microchemical tests were made on air-dry seeds, on seeds which had been fairly well after-ripened at low temperatures, on those which had swollen sufficiently to split the pericarp, and on some which had begun elongation of the hypocotyl. Sections were cut freehand, and tests as suggested by ECKERSON (**13**) were applied.

Macrochemical analyses were made on samples of seeds from the same stages as those studied microchemically. KOCH's (**26**) method was followed rather closely, but with some modifications suggested by Dr. H. R. KRAYBILL. Since the dogwood seeds are quite small, and tend to change in weight and color on being ground, they were put into the samples intact. The alcohol was evaporated from the total extract, leaving 100–150 cc. of solution. Separation was then made by shaking the solution with ether in a separatory funnel. The sugar content was determined by the QUISUMBING-THOMAS (**36**) method, with invertase as the hydrolytic agent for sucrose.

Ammonia and amid nitrogen were determined by distillation under reduced pressure. The apparatus described by VAN SLYKE (**42**) was used. For amino-nitrogen the Van Slyke micro-apparatus was used, and the calculations made on the basis of the table in MATHEWS (**28**). The phosphorus content of the lipoid fraction was determined by the Neumann-Pemberton method and the iodine number by the Hanus method, as described in the Official Methods (**1**).

Studies of respiration were made continuously over a period of 58 days on lots of fifteen seeds each, kept at 6°, 12.5°, and 22° C. respectively, and were then repeated in duplicate on lots of twenty at 2.5–7°, 10–14°, and 20–22° C. respectively for a period of 112 days, followed by eleven days at room temperature (18–26° C.) to permit germination of those seeds which were after-ripened.

For these studies a modification of the apparatus devised by OTA (**32**) was used. Instead of being forced through, CO_2-free air was drawn by suction through the apparatus. As seen from fig. 2, the chief modifications consisted of a train of wash bottles, two con-

taining saturated NaOH and the one next to the apparatus containing saturated $Ba(OH)_2$, and a trap bottle beneath the apparatus to which suction might be applied and into which the normal NaOH used to absorb the CO_2 of respiration might be drawn. A mercury manometer was substituted for the water manometer, the seed chamber being calibrated in order that the O_2 absorption could be calculated roughly from the change in pressure.

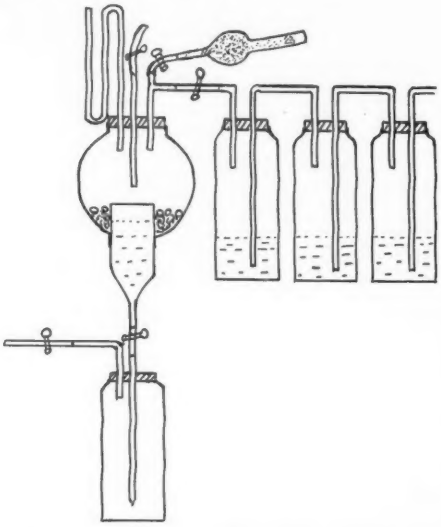

FIG. 2.—Apparatus used for respiration studies

At intervals the manometer reading was taken, along with a record of temperature and barometric pressure. The cup was drained, rinsed with distilled water, and redrained by suction continued long enough to draw out any unabsorbed CO_2, and the apparatus reset as before. The NaOH was titrated as described by BROWN and ESCOMBE (4).

RESULTS

GERMINATION.—When a single seed or lot of seeds of *Cornus florida* is completely after-ripened, a sudden imbibition of water and swelling sufficient to split the pericarp occurs in 6–10 hours at 20° C.,

after which elongation of the hypocotyl becomes apparent in another 6–10 hours. Only occasional freshly gathered seeds swell sufficiently to break the bony layer, after which very slow elongation occurs.

Seeds with the bony layer removed sometimes show abnormally slow elongation of the hypocotyls up to 1 or 2 per cent in either light or darkness. In the light the cotyledons often become green, beginning at the edges where the endosperm layer is absent or extremely thin, then expand, splitting the membrane, and are gradually pushed from the seed by the elongation of that region of the hypocotyl immediately below, which is structurally stem. Such abnormal growth may be followed by a very slow elongation of the hypocotyl, gradually becoming normal in rate, or the hypocotyl may finally be slipped from the parted endosperm by the weight of the expanding upper part of the seedling. In the latter case the hypocotyl may grow or the decomposition of the endosperm may have progressed so far before its release as to kill the delicate tip cells and prevent normal root growth.

Normally, as in seeds with the bony covering intact, the cotyledons seem to act as haustoria for the seedling, while exhausting the stored material of the endosperm. When well expanded, the seedling, like that of many dicotyledons, pulls erect, leaving all seed coverings behind in the soil. The cotyledons then grow and function as true leaves until the third or fourth pair has appeared.

Seeds, whether freshly gathered or those subjected to cold treatment, are not at all uniform as to the depth of their dormancy. However, except for the occasional seed just mentioned, no germination occurred until the seventy-fifth day of cold treatment, and then only from a lot at 10° C.

Of seeds from 0°, 5°, 10°, 15° C., taken from the bottles in duplicates of twenty at intervals of two weeks and put at 15°, 20°, 24°, and 27° C. respectively in petri dishes, the highest percentage germinated from the 0° or 5° lots transferred to 15° C. However, germination at 15° of such partially after-ripened seeds extended over 30 days, while at higher temperatures it was complete in 10 days. The difference in percentage of germination at the different higher temperatures decreased as the length of the cold storage period in-

creased. The tendency of higher temperatures to induce secondary dormancy in incompletely after-ripened seeds decreases with a lowering of the temperature; and though after-ripening does not occur at 15°, the continuance of this process when near completion seems to be favored by that temperature.

Tables I and II show that after-ripening takes place most quickly at 10° in the large petri dishes where there is a considerable volume of air, while in the sand bottle there is such a fall in the percentage at 10° that the 5° temperature becomes most favorable. There usually appeared to be about a ten day to two week interval between the germination of seeds at 10° and 5°, and again between 5° and 0° C.

The petri dish with moist cotton and filter paper seed bed seems to provide sufficient air and moisture for optimum germinative conditions, but only a few of the seeds may be after-ripened at a time in such a container. In addition, the petri dish is rather difficult to keep sterile for a period of 130 days or more.

The moist quartz sand mixture must be aired, and moistened as frequently as every two or three days in a dry atmosphere. Otherwise the water tends to settle, leaving the upper layers dry, and causing a lack of uniformity in after-ripening. In addition there seems to be a lack of air for the seeds at 10° as they approach completion of after-ripening, but with a fairly humid atmosphere at 5°, the sand bottle is quite efficient for quantity production of after-ripened seed. There is little difficulty with molds.

Peat has proven so far the most satisfactory medium for germination, but has been used less extensively than the others. As suggested by HARRINGTON (**17**) for canton flannel, it has the advantage of coming in closer contact with the large seeds without interfering with the air supply. It also maintains a more uniform moisture supply. ECKERSON (**12**) has reported that dilute acid favors after-ripening of *Crataegus mollis*. The pH value of peat is about 4.5, but it is doubtful whether the reaction value is an important factor, since dilute HCl, H_2SO_4, butyric acid, and acetic acid in the concentrations recommended as most favorable by ROSE, appeared to have no effect, and nearly as good percentages of germination were obtained with the other seed beds without acid conditions when the moisture was kept constant. The bottle at 5° mentioned in table I required no airing or moistening during the 112 days, and would probably

TABLE I

AFTER-RIPENING AND GERMINATION UNDER VARIOUS CONDITIONS OF SEED BED AND TEMPERATURE

STORAGE TEMPERATURE (° C.)	FIRST GERMINATION		GERMINATIVE CONDITION	NO. OF SEEDS	TOTAL DAYS	TOTAL PERCENTAGE
	Days to	Percentage				
15	.....	.....	Petri dish	50	160	0
			Sand bottle	100	160	0
			Peat bottle	200	160	0
10–16	.....	.....	Sand bottle	900	160	23
10	107	40.0	Petri dish	50	148	86.0
		28.0	Petri dish	50	148	74.0
		15.0	Sand bottle	100	148	51.0
		32.0	Sand bottle	100	148	53.0
		34.8	Sand bottle	500	179	65.6
5	107	4.0	Petri dish	50	179	74.0
		8.0	Petri dish	50	179	68.0
		13.0	Sand bottle	100	179	78.0
		21.0	Sand bottle	100	179	80.0
		13.6	Sand bottle	500	179	76.0
		.....	Sand bottle	900	82	15.0
		.....	Sand bottle	900	110	45.0
		.....	Peat bottle	200	112	82.0
0	.....	.....	Sand bottle	900	87	21.5
			Sand bottle	900	100	26.0
			Sand bottle	900	113	56.0
			Sand bottle	900	147	78.1
			Sand bottle	900	147	76.0

TABLE II

AFTER-RIPENING AND GERMINATION IN LARGE PETRI DISHES AT LOW TEMPERATURES

TEMPERATURE (° C.)	NO. OF SEEDS	PERCENTAGE GERMINATION AFTER			TOTAL PERCENTAGE	TOTAL DAYS
		107 days	131 days	140 days		
5– 8	150	0.....	44.7	54.7	74.0	160
		0.....	38.0	58.7	76.7	160
		0.....	52.7	60.0	80.0	160
		0.....	6.0	67.3	91.7	190
		0.....	0.0	0.0	86.0	190
10–13	150	17.3.....	56.0	.....	97.3	150
		7.3.....	50.0	.....	95.3	150
		0.0.....	60.7	.....	76.7	140
		14.0.....	90.0	.....	97.0	140
		8.0.....	79.3	.....	82.7	134
		14.3.....	88.7	.....	91.3	134
		14.3.....	83.3	.....	91.7	138

have given a higher germination percentage if left longer at this temperature. All of the materials used require sterilization in a steam autoclave for 30–45 minutes at 15 pounds pressure to insure moderate freedom from infection during the long period of after-ripening.

TABLE III

GERMINATION OF CORNUS FLORIDA SEEDS TRANSFERRED FROM HIGHER TO LOW TEMPERATURE AFTER COMPLETE DROP OF CATALASE

CONTAINER	HIGHER TEMPERATURE		LOWER TEMPERATURE		PERCENTAGE GERMINATION
	° C.	Days	° C.	Days	
Petri dish....	24	51	5	130	88
Petri dish....	27	51	5	130	93*
Bottles.....	10	158	5	74	83
Bottles.....	15	83	5	159	67
Bottles.....	24	96	5	136	86

* Larger percentage here due to less infection.

Table III shows the recovery of seeds which had been put under germinative conditions at temperatures unfavorable for after-ripening. Other seeds were permitted to lie dormant in the soil in flats for more than 130 days, then were placed out of doors in early March. During the month and a half of exposure to temperatures near freezing, almost a fourth of the seeds after-ripened, germinating as soon as the temperature rose.

TABLE IV

GERMINATION OF SEEDS PLANTED IN COLD FRAMES NOVEMBER 28 AND LEFT OVER WINTER

NO. OF SEEDS	CONDITION DURING WINTER	APPROXIMATE WINTER TEMPERATURE	DATE OF MULCH REMOVAL	PERCENTAGE GERMINATION
1000.....	Unmulched	Ground frozen*	.....	51.1
1000.....	3 inch mulch	3° C.	April 1 and April 12	72.2
1000.....	6 inch mulch	3–5° C.	April 1 and April 12	77.3

* Minimum atmospheric temperature during winter −3° F.

The difference in germination of mulched and unmulched seeds, as shown in table IV, may be explained on the basis of individual variability. Germination in the storage bottles at low temperatures continues over a period of 45–50 days. Air-dry seeds (33) or seeds in

the pulp are uninjured by freezing, but freezing wet seeds, which had been in moist sand at 0° C. two weeks and had reached a moisture content of 20–30 per cent, produced 30–40 per cent dead seeds, even when the freezing lasted only a few hours and was so light as merely to make the sand cling together in the bottles. A still briefer exposure to freezing proved completely fatal among seeds which had reached the final stage of after-ripening, and had broken their bony covering. Seeds, then, which reached this stage during warmer days of January or February, were killed by subsequent cold weather. Seeds in the mulched beds were not subjected to freezing. Several cracked seeds, with kernels decayed, were found on the bare ground under trees in March and April.

The mulched beds contained several seeds which did not completely after-ripen in a single winter, and also some injured ones, for quite often there are slight insect or fungus injuries in the kernels of freshly collected seeds.

The percentage of killing as shown by table V was much higher for seeds overwintering in moist sand than for those covered with an inch of soil. One would expect the soil temperature to remain higher than that of sand, which has no organic matter. Since the bottles in the sandpit were all inclined mouth downward at an angle of 15°, there was no evaporation from the tops, and the moisture remained quite uniform throughout.

The gradient of decreasing soil moisture content was from the greatest toward the least depth, but the differences were insufficient to affect the results to any marked degree. The atmospheric temperature when the seeds were removed from the pit was still quite variable, falling to freezing or below much of the time. That probably accounts for the fact that the highest percentage of germination was obtained from seeds at the greatest depth, for there the minimum temperature was higher. The final differences in germination between the two more deeply buried lots was probably due to the individual variability of the seeds composing them.

Storing seeds intact in the pulp does not appear successful under any condition. Seeds which had been stored moist in the pulp in rather open containers at 30° F. from October until the last of February, showed 30–40 per cent infection with *Fusarium*, *Penicilli-*

um, and *Aspergillus*, while the same seeds had reached 60–70 per cent infection by the end of March. Of seeds stored similarly at 50° F. until the end of February, 100 per cent showed bacterial infection, in some cases accompanied by *Penicillium* and *Aspergillus*. Seeds sterilized with pulp intact, stored at low temperature in sand bottles, and those buried at greater depths were infected chiefly with bacteria, but those buried near the surface contained in addition a black soil fungus.

Observations and collections made in the woods during the spring and summer proved that when *Cornus florida* seeds had lain under leaves in a moist situation during the winter, they germinated as

TABLE V

GERMINATION OF SEEDS BURIED IN SAND BOTTLES OCTOBER 21

No. of seeds	Depth in inches	Condition	Percentage germination while buried	Days buried	Total percentage germination	Days after removal
200.....	1–3	Free of pulp	8.5	176	13–	14
200.....	4½–6½		54.1	176	91.8–	14
200.....	10½–12		64.0	176	88.5	14
100.....	1–3	Sterilized in pulp	0.0	176	0.0	30
100.....	4½–6½		0.0	176	0.0	30
100.....	10½–12		0.0	176	0.0	30

early as the middle of April and came up through the leaves. Seeds in less moist situations among the leaves required cold treatment before germination, and were in some cases still in the scarlet fruit. Seeds under trees where the ground was nearly bare were frequently all gnawed open by the squirrels, but even where unmolested were either cracked and decayed or required a period of low temperature. No seedling of a few years' growth could be seen where the natural condition of the ground seemed to be that of comparative lack of covering of any sort.

At a nursery on Long Island a dogwood tree was growing in the midst of a field of rhododendrons. During the winter the ground had been mulched. In August large numbers of young dogwood seedlings grew vigorously around the tree over a radius of several feet.

CATALASE.—The results of a preliminary test as to the effect on catalase activity of soaking the ground seed material appear in

fig. 3. The temperature chosen as most favorable for soaking without the introduction of the effects of bacterial action was 15°. There was no apparent change in the catalase until about the tenth hour.

The results shown in the tables, with the exception of those in table VI, were calculated to 0° C., and 760 mm. pressure for 0.1 gm. wet weight, which is the equivalent of 0.06 dry weight. The results represent the average for three to five runs. As may be seen from table VI, the catalase content of a lot of seeds, as measured by O_2 liberated, may not be at all proportional to their weight. The catalase content seems rather to depend on the condition of the seeds.

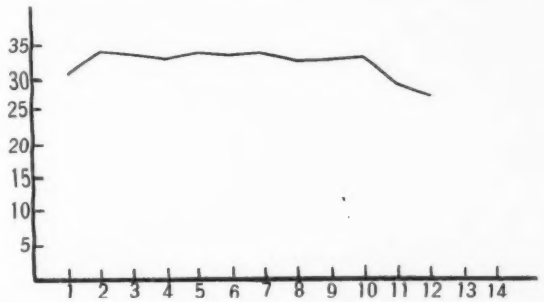

FIG. 3.—Effect on catalase activity of soaking ground material: vertical axes represent cc. O_2 liberated in 10 minutes per 0.5 gm. air-dry weight; horizontal axes represent hours of soaking.

Table VII and fig. 4 show the effect on catalase activity of *Cornus florida* seeds of storage at different temperatures under germinative conditions. Catalase activity and germinability are closely correlated in these seeds. Both show great individual variation; both increase under storage at low temperatures; and both are decreased by higher temperatures, germination being inhibited where the catalase drops below that for air-dry seeds. A similar drop in catalase accompanied by reduced vigor in germination has been reported by SHULL and DAVIS (40) for non-germinating *Xanthium* uppers with coats intact, kept in the germinator for a long period. DAVIS (9) and others, working in the laboratories at the Boyce Thompson Institute, have noted the same drop in catalase, but in these latter instances it is associated with a deepening of original dormancy or a

secondary dormancy, such as is suggested by table VIII for *Cornus florida*. Germination had begun by the eighty-fifth day in the lots at 0°, 5°, 7°, and 10° C., but unsplit seeds were selected for catalase determinations. All the seeds used were taken from the sand bottles, in which, as noted, there was a drop in germination at 10° C. Seeds which had dropped extremely low in their catalase content were slow at first in resuming it at low temperatures, as indicated in

TABLE VI

WEIGHT VS. INDIVIDUAL VARIATION AS FACTORS RELATED TO CATALASE ACTIVITY IN AIR-DRY CORNUS SEEDS

No. of seeds	Grams	Cc. O_2 liberated at 25° C. in		
		2 minutes	5 minutes	10 minutes
6	0.0798	33.3	42.8	49.9
	0.0748	29.4	38.2	46.2
	0.0787	35.7	41.6	53.8
	0.0699	34.0	43.2	50.8
	0.0763	29.6	37.7	45.0
4	0.0543	27.4	35.3	43.6
	0.0608	20.3	27.0	35.1
	0.0468	22.5	29.2	36.6
	0.0445	25.4	33.0	40.6
2	0.0293	12.6	16.8	21.2
	0.0254	12.8	16.0	20.4
	0.0335	9.4	12.6	15.0
	0.0250	11.1	14.4	17.7
	0.0259	13.8	18.4	22.6

table IX, but their recovery is complete as gaged by either catalase or germinative behavior.

DAVIS (9) has devised a test by which living and dead seeds may be distinguished on the basis of catalase content before and after soaking. The catalase content of dead seeds falls markedly on soaking, while that of living seeds remains nearly constant. The results of such a test applied to seeds of *Cornus florida* may be seen in table X. The catalase activity had in the beginning increased most noticeably in the lots of seeds at an alternation between freezing and 5° C.; however, after the second freeze and thaw the seeds were all dead. The catalase remained approximately what it had been at the time of kill during the two or three days the seeds were

left at 5° C. In less than 24 hours after their removal to room temperature bacterial action and disintegration had taken place in every seed. Seeds which had been stored at 15° prior to killing by freezing retained the much lower catalase content they had shown before freezing, but lost nearly half of that on soaking. The amount

TABLE VII

EFFECT OF TEMPERATURE ON CATALASE ACTIVITY OF SEEDS STORED UNDER GERMINATIVE CONDITIONS

DAYS STORED	CC. O_2 LIBERATED PER UNIT DRY WEIGHT IN 10 MINUTES AT DIFFERENT TEMPERATURES (C.)									
	0°	5°	7°*	10°	12°*	15°	17°*	20°	24°	27°
0	43	43	43	43	43	43	43	.....	.....	.....
25	43	44	53	41	46	41	37	.....	.....	.....
37	38	48	41	61	35	44	25	.....	.....	.....
56	43	53	39	47	34	34	20	.....	.....	.....
65	37	.....	41	.....	28	16	.....	.....	.....	.....
74	43	72	47	47	29	34	19	.....	.....	.....
83	47	.....	47	.....	29	.....	19	.....	.....	.....
95	59	58	64	41	38	25	17	.....	.....	.....
130	.....	99	.....	62	.....	26	.....	16	15	10
Split seeds	90–121 cc.	.....	0.5 on radicle-169 cc.							

* Fluctuating but approximately as given.

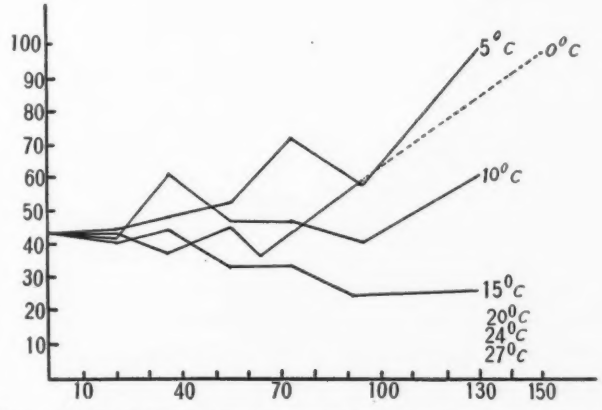

FIG. 4.—Effect of different temperatures under germinative conditions on catalase activity of seeds: vertical axes represent cc. of O_2 liberated in 10 minutes per unit of dry weight; horizontal axes represent days.

of drop seems to increase with a rise in soaking temperature, but in every case for *Cornus florida* seeds there is a noticeable drop for

TABLE VIII

EFFECT ON CATALASE ACTIVITY OF TRANSFER FROM LOW TO HIGHER TEMPERATURES BEFORE COMPLETION OF AFTER-RIPENING

LOW TEMPERATURE		HIGH TEMPERATURE		CC. O_2 LIBERATED IN		
°C.	Days	°C.	Days	2 minutes	5 minutes	10 minutes
.....	.....	20	95	6.6	11.3	14.1
15.....	53	20	43	7.3	13.5	17.0
10.....	53	20	43	11.8	20.4	26.4
5.....	53	20	43	14.0	23.9	30.2
0.....	53	20	43	11.0	20.0	26.2
.....	.....	24	95	.....	8.8	11.4
5.....	53	24	43	14.0	19.4	23.3
0.....	53	24	43	7.7	13.8	18.4
10.....	53	27	11	5.1	8.2	11.2
5.....	53	27	11	7.0	12.0	16.0
0.....	53	27	11	9.1	14.0	17.4

TABLE IX

EFFECT OF COLD TREATMENT FOLLOWING HIGH TEMPERATURES UNDER GERMINATIVE CONDITIONS

HIGH TEMPERATURE		LOW TEMPERATURE		CC. O_2 LIBERATED IN		
°C.	Days	°C.	Days	2 minutes	5 minutes	10 minutes
15	83	5	12.....	7.3	14.2	19.0
			26.....	7.0	12.4	15.6
			42.....	9.0	20.7	25.3
			62.....	14.5	.....	31.8
			82.....	22.5	37.0	45.0
			159.....	68% had germinated at 5° C.		
24	101	5	8.....	3.6	7.0	9.0
			24.....	6.2	12.2	16.2
			44.....	7.0	13.6	18.0
			64.....	11.0	19.6	24.0
			136.....	86% had germinated at 5° C.		

soaked dead seeds, even when the original content is quite low. For living seeds soaked intact, the catalase remains constant or in most cases increases slightly.

MICROCHEMICAL TESTS.—The results of microchemical tests appear in table XI. *Cornus florida* seeds have a high protein content, occurring as aleurone grains packed closely in the cells and surrounded by a fat which squeezes out of the cut surface and forms large drops over and around the sections. After the imbibition of water into the seed, these grains become irregular in shape, and finally break down in the embryo and adjoining endosperm as swelling occurs. Color reactions indicate the presence of protein materials and hydrolytic products where the aleurone grains have disappeared. The biuret reaction has changed from bluish to pinkish lavender at the close of after-ripening, and an amino acid which has

TABLE X

EFFECT OF SOAKING INTACT SEED ON CATALASE ACTIVITY OF LIVING AND DEAD SEEDS

DESCRIPTION OF MATERIAL	CC. O_2 LIBERATED IN 10 MINUTES FROM			
	Soaked	Temperature (C.)	Hours	Unsoaked
Killed by freezing	20.6	15	24	33
	19.6	20	24	.....
	17.3	32	24	.....
Air-dry, living	37.2	15	24	35.5
5° C. stored 83 days	43.3	15	36	40.0

not been identified crystallizes out on the addition of absolute alcohol.

Air-dry seeds in a great many cases show no trace of starch, but some may contain a considerable amount, as indicated in fig. 5, which shows the starch content at later stages as well. As after-ripening progresses the starch content increases, until the hypocotyl, lower part of the cotyledons, that part of the endosperm adjoining the hypocotyl, and the two outer layers of endosperm cells over the rest of the seed become well packed with grains. In the third layer of the endosperm occasional smaller grains appear in active movement. At this stage the seed is likely to germinate quickly on removal to room temperature. The starch grains then disappear, beginning at the hypocotyl tip. Seeds at 10° presented in some cases on the forty-fourth day the same apparent starch content as those

at 5° for 74 days, but other seeds at 5° showed a content equal to that of completely after-ripened seeds. Acidity conditions were difficult to ascertain by colorimetric methods, since there was adsorption of the dye, for cresol purple, at the critical point. However, the cell contents aside from the adsorbing proteins appeared to remain about 6.2–6.4 throughout the period of after-ripening. Other changes may best be discussed under macrochemical results,

TABLE XI

MICROCHEMICAL TESTS ON SEEDS OF CORNUS FLORIDA

SUBSTANCE	FORM	TEST	AIR-DRY	AFTER-RIPENED	SWOLLEN TO SPLIT PERICARP
Lipoid	Matrix	Sudan	+++++	+++++	+++++
Protein	Aleurone	Xanthoproteic	+++++	+++	Gone from hypocotyl tip and surrounding endosperm
		I. K. I.	+++++	+++	
		Millon's	+++++	+++	
	Soluble	Same as preceding	+	+++	+++++
		Biuret	Blue-lavender	Pink-lavender	Pink-lavender
Amino acid	.....	Crystallization	.....	?	++++
Sugar	Reducing	Flückigen	Trace	Trace	Trace
		Phenylhydrazine osozones	Trace	Trace	Trace
		Methyl phenylhydrazine osozones	–	–	–
	Sucrose	Hydrolysis flückigen	+++	++++	+++
		Phenylhydrazine osozones	++	++++	+++
Phytosterol	.....	H_2SO_4	+	+	+
Acidity	.....	Indicator series	6.0–6.4	6.0–6.4	6.0–6.4
Pectic lamellae	.....	Methylene blue	+	+	+
		Ruthenium red	+	+	+
Cellulose	.....	Polarization	+	+	+
		Hydrocellulose	+	+	+
Starch	Localized	Iodine	– to +	+++++	+++
		Polarization	– to +	+++++	+++

since the microchemical tests were preliminary to quantitative determinations.

MACROCHEMICAL RESULTS.—The results of chemical analyses of *Cornus florida* seed appear in table XII. PACK (34) obtained similar results in many cases for *Juniperus* during after-ripening and early seedling growth. He has discussed quite fully the probable chemical and physiological interpretations of his results. However, the seedling stage he has considered is somewhat further advanced than the stage studied for *C. florida*.

Similarly, MILLER (27) for the sunflower, and GREEN (15, 16) for *Ricinus* have studied germination well advanced in oily seeds, while CHOATE (5), JODIDI (22), and FODOR and REIFENBERG (14) have discussed protein changes at similar stages in wheat, corn, and peas. Their results of course show more pronounced differences as to fats and protein between the air-dry seeds and the seedling conditions.

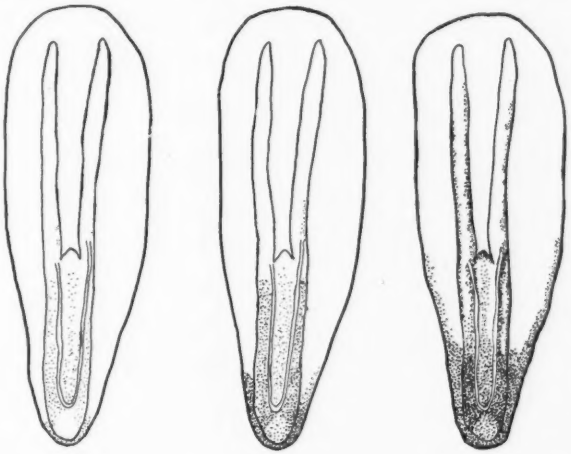

FIG. 5.—Starch accumulation during after-ripening of seeds of *Cornus florida*: *A*, air-dry (maximum); *B*, 42 days at 5° C. (maximum); *C*, 44 days at 10° (maximum); 74 days at 5° (minimum).

The general direction of change is indicated first by an accumulation of active, readily utilized materials such as sucrose, starch (localized in the hypocotyl and adjoining endosperm), amino acids, and soluble proteins during the after-ripening period, and the utilization of part of these following the intake of water as germination begins, accompanied by further breakdown or hydrolysis of the more stable fats and proteins. One might consider the increase of sucrose with increased osmotic activity as perhaps the chief factor in the swelling process which initiates germination. The 2 per cent increase does not represent the total difference between the

sugar content of an air-dry seed at the earliest stage and one completely after-ripened, but rather the difference between the average

TABLE XII

RESULTS OF MACROCHEMICAL DETERMINATIONS CARRIED OUT ON SEEDS OF CORNUS FLORIDA

	AIR-DRY		AFTER-RIPENED		SWOLLEN TO SPLIT CARPELS AND SOME GERMINATED	
	a	b	a	b	a	b
Total gm. dry weight	18.84	18.84	19.9386	.....	27.6742	.....
Percentage moisture	5.8	5.8	42.7	.....	53.8	.....
Total F_3 in gm.	7.348	7.342	7.466	.....	10.423	.....
Total as percentage dry weight	39.0	39.45	37.45	.....	37.7	.....
Total solids F_2 in gm.	2.295	2.363	3.526	.....	4.017	.....
Total as percentage dry weight	12.2	12.5	17.7	.....	14.5	.....
Total F_1 gm.	9.197	9.047	8.947	.....	13.234	.....
Total as percentage dry weight	48.8	48.0	45.0	.....	48.5	.....
Total nitrogen in F_1	0.0	0.0	0.0	.....	0.0	.....
Phosphorus of F_1 as percentage of F_1	0.124	0.119	0.142	0.118	0.132	0.121
Phosphatides as percentage of dry weight	1.57	1.47	1.65	1.37	1.65	1.51
Saponification number	283.0	.....	.....	.....	.....	.....
Iodine number, dry weight	137.0	139.0	137.0	139.0	136.0	126.0
Free fatty acid as cc. N/10 per 100 gm.	47.0	.....	.....	.....	48.4	.....
Starch per 0.8 gm. sample by hydrolysis with HCl	0.0	0.0	0.0	0.0	0.0	0.0
Starch per 0.8 gm. sample by takadiastase method	0.0	0.0	0.0	0.0	0.0	0.0
Percentage reducing sugars	0.584	0.583	0.348	.....	0.311	0.351
Percentage sucrose	6.05	6.0	8.37	8.44	6.53	6.56
Nitrogen of F_3 as percentage of F_3	13.9	13.4	12.38	12.31	12.74	12.66
Protein as percentage of dry weight	33.88	33.04	28.98	28.81	30.02	29.83
Total nitrogen in F_2 as percentage dry weight	0.185	0.19	0.539	0.536	0.712	0.705
Amino nitrogen in F_2 as percentage dry weight	0.082	0.083	0.221	0.217	0.672	.....
Ammonia nitrogen in F_2 as percentage dry weight	0.00743	.....	0.03773	.....	0.04434	.....
Amid nitrogen in F_2 as percentage dry weight	0.0215	.....	0.04376	.....	0.05342	.....

for a lot of seeds, many of which will swell slowly when the pericarp is removed, and a second lot, part of which may be fully after-ripened but many of which may be still quite retarded.

So early in germination a difference in the lipoid content of the seed has not become apparent, but at later stages, when the hypocotyl is about 1 cm. long, the fat begins to decrease around the hypocotyl and then around the rest of the embryo. A difference in lipoid dispersion as reported by PACK (35) was not established, nor was there any apparent difference in phosphatide content.

The moisture content apparently changes little for intact seeds in contact with a moist seed bed, until after-ripening is practically complete. For air-dry seeds at all temperatures the moisture content reached about 38 per cent after three weeks, rose to 40–42 per cent where it remained until the close of a period of over 100 days, after which it reached from 48 per cent for barely split seeds to 60 per cent for those with elongating hypocotyls.

No difference in acidity was detected by colorimetric methods or by the quinhydrone potentiometer method. In the latter case, since it was necessary to add some redistilled water to the tissue of air-dry seeds, the same amount was added to the imbibed ones. However, the tests were preliminary, and the effect of change in concentration of the solutions was not determined. The pH was apparently between 6.0 and 6.4 throughout the endosperm and embryo until the hypocotyl was nearly 1 cm. long, at which time the outer layer of embryo cells and the sieve tubes showed a pH of 4.4–4.6.

RESPIRATION.—Due to a lack of thermostatic control, the probable error in O_2 data as calculated from the manometer readings seemed too great to warrant the use of these data in determining the respiration quotient. There was very noticeably greater O_2 absorption at 20–22° C. than at the lower temperatures, however, and somewhat greater at 10–14° than at 2.5–7° C.

Tables XIII and XIV show the CO_2 produced in two sets of experiments. In both cases there is a large decrease in CO_2 output at the lower temperatures during the period of after-ripening, with the lowest amount produced at the lowest temperature, that is, that already found the most favorable for after-ripening. The seeds at 2.5–7° C. showed a large increase in CO_2 output, accompanied by rather vigorous germination when placed at room temperature following long cold storage, while those at 10–14° showed some in-

crease in CO_2 but only a feeble tendency to germinate. Several of the woody coverings cracked but germination did not proceed further.

TABLE XIII

MG. CO_2 PER 15 SEEDS PER HOUR (PRELIMINARY)

PERIOD IN DAYS	6° C.	12.5° C.	22° C.
1 to 6th	0.0411	0.0302	0.0489
6–11	0.0307	0.0308	0.08635
11–16	0.0113	0.0213	0.0639
16–22	0.0328	0.0567	0.136
27–34	.....	0.0124	0.06623
34–41	0.013	0.0271	0.0326*
41–49	0.0212	0.0405	0.0585
49–58	0.0166	0.0309	0.0581

* At 10° or below for 48 hours.

TABLE XIV

GM. CO_2 PER KG. PER HOUR

PERIOD IN DAYS	2.5°–7° C.		10°–14° C.		20°–22° C.	
	a	b	a	b	a	b
1 to 7th	0.1897	0.26112	.....	0.2679	0.395	0.3889
7–14	0.1664	0.154	0.167	0.128	0.243	0.318
14–21	0.0842	0.0912	0.145	0.150	0.174	0.234
21–28	0.0996	0.101	.....	0.183	0.558	0.442
28–42	0.0734	0.0577	0.125	0.0799	0.329	0.209
42–56	0.0553	.....	0.0866	0.0852	0.178	0.292
56–70	0.0796	0.1049	0.109	0.0595	0.246	0.340
70–84	0.0672	0.0824	0.121	0.03004	0.247	0.244
84–98	0.0924	0.0752	0.0574	0.0652	0.215	0.214
98–112	0.1043	0.1042	.....	0.09	0.154	0.370
After 11 days at room temperature (18°–26°C.)	.....*	0.237†	0.140	0.215	0.111	.....*

* The strain on the apparatus of the fluctuating room temperature produced leaks, so that NaOH overflowed on the seeds, killing a large percentage.

† Fifty per cent of the seeds were well germinated at the end of the period at room temperature.

II. Sambucus canadensis

Two lots of seeds of *Sambucus canadensis*, referred to in the following pages as lot 1 and lot 2, were used for the present study. The first of these was collected in Pennsylvania about October 15. The berries were small and black, of the usual type, the seeds weighing on an average 1.5 mg. each. The second lot was collected in northern Indiana on a low black soil. They ripen about the last of October in this locality, and have a berry somewhat larger than

those from Pennsylvania. The seeds weigh on the average 2.84 mg. each, and look twice as large as those of lot 1.

The seeds were washed free from the pulp, sterilized one-half hour in 0.25 per cent uspulun, and washed thoroughly with distilled water, after which they were put under germinative conditions. About 18 per cent of the seeds in each lot was empty; these floated and were poured off during the washing. Part of each lot was stored air-dry and later used for germinative tests.

GERMINATION RESULTS.—Seeds treated with concentrated H_2SO_4, N/400 acetic acid, and 2, 1, and 0.2 per cent thiourea, urea nitrate, saccharin, and caffeine showed no increase in germination. As may be seen in table XV, those seeds which had been stored at low temperatures, but were not yet after-ripened or fully recovered from dormancy, seemed to benefit from treatment with KNO_3. A solution of N/200 salt was used to moisten the filter paper seed bed in petri dishes. When used with sand it produced no increase over the checks. When added to a non-germinating lot of seeds, those which had been stored air-dry or had ceased germination at an unfavorable temperature, the KNO_3 solution failed to bring about germination.

Seeds planted in the greenhouse during the autumn while sunny days were frequent, and again in the spring, gave good germination, extending from the fourteenth to the thirtieth day after planting. One thousand air-dry seeds of lot 2 put in the 17° C. greenhouse in November remained dormant 56 days, were put at 5–7° for 35 days, then again at 17° in late March as the sun became warm during the day. After 55 days 58 per cent had germinated, at which time the greenhouse temperature had become nearly constant above 20° C. Five hundred seeds air-dried for 13 days gave 55 per cent germination on the hot plate of a 10° oven where the fluctuation was between 10 and 20° C.

Undried seeds of lot 1 without cold treatment gave no germination at 10° or any constant temperature above, but seeds of lot 2 gave scattered germination at all temperatures tried; not exceeding 4 or 5 per cent, however, for any constant temperature. Seeds of lot 1 stored at 10° which showed no germination after 101 days, when shifted to 5°, were germinating well by the 138th day at 5° C.

TABLE XV

GERMINATION UNDER DIFFERENT CONDITIONS OF LOT 2 SEEDS OF SAMBUCUS CANADENSIS STORED AT 0° C. IN MOIST BUILDING SAND

MEDIUM FOR GERMINATION	TEMPERATURE (C.)	AFTER 85 DAYS' STORAGE	AFTER 99 DAYS' STORAGE		AFTER 132 DAYS' STORAGE
		6 weeks	2 weeks	6 weeks	20 days
Petri dish H_2O	10	.....	23	26	.....
Petri dish KNO_3	10	.....	30	37	.....
Petri dish H_2O	15	17	35	35	73.0
Petri dish KNO_3	15	44	44	57	.....
Sand bottle H_2O	15	72	.....	.....	.....
Petri dish H_2O	20	11	36	41	.....
Petri dish KNO_3	20	55	52	67	71.0
Sand bottle H_2O	20	71	.....	.....	.....
Petri dish H_2O	24	.....	27	28	.....
Petri dish KNO_3	24	.....	47	49	.....
Petri dish H_2O	27	.....	18	20	64.0
Petri dish KNO_3	27	.....	36	41	.....
Petri dish H_2O	32	.....	12	13	.....
Petri dish KNO_3	32	.....	10	17	.....
Petri dish H_2O	10–20	.....	42	68	.....
Petri dish KNO_3	10–20	.....	58	81	.....
Petri dish H_2O	10–24	.....	49	69	.....
Petri dish H_2O	10–27	53	46	68	85.0
Petri dish KNO_3	10–27	88	56	82	.....
Sand bottle H_2O	10–27	91	.....	.....	.....
Petri dish H_2O	10–32	.....	47	62	85.5
Petri dish H_2O	15–20	.....	37	54	.....
Petri dish KNO_3	15–20	.....	57	76	.....
Petri dish H_2O	15–24	.....	45	57	.....
Petri dish H_2O	15–27	42	47	57	73.0
Petri dish KNO_3	15–27	77	60	79	.....
Sand bottle H_2O	15–27	90	.....	.....	.....
Petri dish H_2O	15–32	.....	50	58	77.0
Petri dish H_2O	20–27	.....	33	41	.....
Petri dish H_2O	20–32	.....	37	45	.....
Petri dish H_2O	17 (Greenhouse)	29	47	57	70.0
Petri dish KNO_3	17 (Greenhouse)	87	61	83	.....
Sand bottle H_2O	.....	87	.....	.....	.....

Tables XVI and XVIII show the percentage of germination for seeds in bottles buried over winter, and for those planted in beds

TABLE XVI

GERMINATION OF LOT 1 SEEDS OF SAMBUCUS CANADENSIS IN SAND BOTTLES AT VARIOUS TEMPERATURES

No. of seeds	Condition of storage	First germination			Days* to completion	Total per-centage
		° C.	Days to	Percentage		
1000	5° in moist sand 82 days	10	8	0.3	57	2.8
		15	8	3.5	18	8.0
		20	8	16.2	29	33.3
		24	8	11.4	36	14.1
		27	8	0.0	15	0.3
		32	8	0.0	.....	0.0
2500	5° in moist sand 82 days	10–15	.....	.....	.....	0.0
		10–20	15	3.5	64	30.4
		10–24	8	0.8	57	9.0
		10–27	8	14.4	57	87.3
		10–32	8	1.3	57	49.8
2500	5° in moist sand 82 days	15–20	8	4.8	Bad freeze on 18th day	22.0
		15–24	8	.....		22.0
		15–27	8	.....		53.4
		15–32	8	.....		29.1
1000	5° in moist sand 82 days	20–27	8	6.1	29	5.0
		20–32	8	.....	29	12.0
2500	5° in moist sand 82 days	16–24	.....	.....	72	50.8

* Total days left at given temperature, 72.

TABLE XVII

GERMINATION OF LOT 1 SEEDS OF SAMBUCUS CANADENSIS BURIED IN SAND BOTTLES IN SAND PIT OCTOBER 18 AND LEFT UNTIL APRIL 15

No. of seeds	Depth in inches	Percentage H_2O in sand April 15	Percentage germination		Days after removal
			While buried	Total	
3700.....	2–4	2.0	57.9	64.1	44
4750.....	4½–6½	2.5	18.8	30.0	44
5400.....	10½–12	3.0	1.1	43.3	44

November 28. The cold winter temperature prepared the seeds for germination, and the fluctuating temperatures of March and April

produced the highest percentage of seed growth. Seeds buried more deeply or those protected by a mulch did not get the benefit of this alternation of temperatures.

All the seeds from the sand pit were placed in the greenhouse, where there was alternation of temperature for about a month. As may be noted, rather rapid germination occurred in all the bottles, but the ones buried more deeply contained the largest number of seeds which were ready for germination as soon as optimum conditions were provided. These optimum conditions, as determined from the experiments shown in table XVI, from moisture determinations

TABLE XVIII

GERMINATION OF LOT 1 SEEDS PLANTED IN COLD FRAMES NOVEMBER 28

No. of seeds	Condition	Inches of mulch	Percentage of seedlings		Mulch removed
			May 5	May 27	
200	Undried	0.0	54.0	59.0	April 1 and 12
		3.0	22.5	22.5	
		6.0	28.5	28.5	
1000	Air-dry	0.0	47.9	47.9	April 1 and 12
		3.0	11.9	22.2	
		6.0	43.0	43.0	

on the sand of different lots, and from catalase studies, seem to be a daily alternation of temperature between 10° and 27°, and a moisture content in the sand of 2.5 to 3 per cent. Results obtained at 10–32°, 15–27°, and 15–32° may be nearly equal to those obtained at 10–27° C. All alternations used consisted of 17 hours at the lower temperature and 7 hours at the higher.

After 130 to 140 days storage at low temperatures, a high percentage of the seeds usually were found split open. These begin growth readily at 20° and 24°, but may be retarded by 27° C. The seedlings are not very susceptible to injury of any kind, and grow quite rapidly at temperatures of 20° or above. The cotyledons expand and serve as leaves until overshadowed by other leaves. The fourth pair of true leaves is usually compound, and did not appear until the eightieth or ninetieth day on seedlings grown at 17–18°.

Seeds of either lot 1 or lot 2 show recovery from exposure to 32° under germinative conditions. From seeds so stored 112 days, 81 per cent germination was obtained within a week after 130 days at 5° (46 per cent had germinated at the close of the 130 days at 5° C.; the remaining 35 per cent after 7 days at 10°–24°).

Alternation alone has never brought air-dry seeds which were put under such germinative conditions to a high percentage of germination, but has caused increased scattered germination in lot 2 seeds. Only following cold treatment of 82–100 days for seeds of lot 2, and 90–130 days for seeds of lot 1 does it prove entirely effective. Catalase studies have shown that alternation has an effect on the activity of air-dried seeds.

Lot 1 seeds were not dormant when washed free from the pulp, for they responded to temperature alternation. The dormancy of seeds of lot 2 may have been due to their having been overheated in the pulp, while enroute by mail. When both lots were air-dry, the seeds of lot 2 responded more quickly to cold treatment or alternation of temperature than those of lot 1.

Most of the seeds subjected to repeated freezing and thawing were killed by the second freeze and thaw, and the killing was complete after the fourth alternation. A few hours' freeze produced a large number of dead seeds among unsplit seeds stored at 15°, although they were allowed to thaw undisturbed at a temperature just above freezing. A brief period of freezing among those ready to germinate and in some cases already split killed the entire lot.

CATALASE.—For catalase studies the seeds in most cases were not weighed, but counted in lots of 50 for lot 1 and 25 for lot 2. Where the catalase content was greatly increased, as in the germinated seeds, smaller numbers were used. The seeds were ground for 2 minutes with 2 cc. distilled water, clean quartz sand, and a little $CaCO_3$; diluted with 13 cc. water; and run for catalase in the same way as the *Cornus* seeds. The results appear in table XIX. There is a definite drop in catalase, even below that of the air-dry seed when the seeds of *Sambucus canadensis* are exposed in a moist condition to a temperature of 27° C. Air-dry seeds when placed moist at 0° or 5° steadily increase in catalase content up to the eighty-fifth day, when germination begins. Seeds tested at that time may

show a higher catalase content than ungerminated ones selected at a later date. This is especially true if seeds removed to alternating temperatures are tested for catalase content on removal from the

TABLE XIX

CATALASE ACTIVITY OF SEEDS LOT 1 AND LOT 2 OF SAMBUCUS CANADENSIS STORED UNDER DIFFERENT CONDITIONS

LOT	NO. OF SEEDS	CONDITIONS OF STORAGE	CC. O_2 LIBERATED IN 10 MINUTES	
			1	2
1	50	Air-dry; moist 98 days at 27°	3.0	3.9
		Air-dry 178 days	5.1	5.4
		Air-dry; moist 31 days at 5°	8.4	8.0
		Air-dry; moist 67 days at 5°	8.0	9.4
		Air-dry; moist 178 days at 5°	16.9	17.7
		Moist 104 days at 0°	15.0	9.5
		Moist 104 days at 10°	9.25	.....
		Moist 104 days at 20°	7.5	8.0
		Air-dry 104 days	5.0	7.5
		Moist 113 days at 5°	13.2	11.0
		Moist 113 days at 5° and 15° for 16 days; 2 mm. radicles	77.0	.....
		10–27° C. 16 days; 5–3 mm. radicles	93.0	.....
		Moist 113 days; 15° 16 days ungerminated	11.0	11.2
		Moist 113 days; 20° 16 days ungerminated	8.4	10.8
		Moist 113 days; 10–27° 16 days ungerminated	13.2	.....
		Moist 113 days; 10–32° 16 days ungerminated	10.8	.....
		Air-dry 81 days; 15° 92 days	6.8	5.2
		Air-dry 81 days; 10–27° 92 days	8.7	8.0
2	25	Air-dry; moist 98 days at 27°	3.7	4.0
		Air-dry 178 days	7.3	5.2
		Air-dry; moist 31 days at 5°	8.7	7.6
		Air-dry; moist 67 days at 5°	15.2	15.1
		Air-dry; moist 165 days at 5°	20.0	22.8
		Air-dry 81 days; moist 92 days at 10–27°	14.3	13.4
		Air-dry 86 days; moist 92 days at 10–27°	7.7	8.7
		Moist 113 days at 5° ungerminated	20.4	22.7
		Moist 113 days at 5° germinated	58.5	82.5
		Moist 113 days at 5° 16 days	23.3	.....
		Moist 113 days at 5° 20° 16 days	13.9	.....
		Moist 113 days at 5° 10–27° 16 days	18.7	18.8
		Air-dry 63 days; 15° 92 days	10.4	9.6

low temperature, and again after the period of alternation has been sufficient to allow germination of most of the fully after-ripened seeds.

Constant temperatures of 15° and above under germinative conditions are less favorable for an increase in catalase than an alterna-

tion of 10° or 15°, but a constant temperature of 15° or 20° is more favorable than air-dry storage. Increased catalase activity is apparently closely correlated with increased seed activity leading to germination, and in most cases may therefore be used as an indication of seed condition.

III. Berberis thunbergii

The present study of seeds of *Berberis thunbergii* is a brief continuation of work done by MORINAGA. Slightly different methods and temperatures were used, but the results check those he reports rather closely.

TABLE XX

GERMINATION OF BERBERIS THUNBERGII AT ALTERNATING TEMPERATURES

°C.	PERCENTAGE GERMINATION AFTER 36 DAYS*		COLLECTED APRIL 12, 5°, IN PULP 18 DAYS
	Air-dry, 151 days	Moist at 5°, 151 days	
5–20	4	68	.....
5–24	18	68	37
5–27	.....	.....	60
10–20	36	72	45
10–24	86	60	78
10–27	.....	80	96
15–20	0	57	2
15–24	40	78	19

* Duplicates of 50 seeds used; mold was the chief interfering factor.

In most cases the seeds were mixed with moist peat in wide mouthed bottles. Those seeds gave better results than seeds mixed with building sand, and germination in quartz sand was obtained only in the bottom of the bottle.

As MORINAGA found, *Berberis thunbergii* seeds germinate best at an alternation between 10° and a higher temperature, but the higher temperatures found equally favorable were 20°, 24°, and 27° C. A period of over 100 days at 5° will give good germination. A brief cold period of 30 to 40 days seems to favor germination at the less favorable temperatures, but has little or no effect at the optimum alternation.

Seeds planted in cold frames over winter (table XXII) tended to

TABLE XXI

GERMINATION OF BERBERIS THUNBERGII UNDER DIFFERENT CONDITIONS

No. of seeds	Date of collection	Condition of storage	Germination		Total per-cent-age	Days
			Medium	° C.		
240	November 12	Dry in pulp 120 days at 8°	Peat bottle	5	93.8	101
240				10	61.2	101
				10–25	98.6	38
		.....	Peat bottle	5	97.1	63
		.....		.....	90.0	63
450		.....		10	35.0	63
420		.....		.....	30.0	63
450		.....		15	.....	101
300	March 10	.....		.....	.....	11
450		Moist peat 29 days at 5°	Petri dish	24, then	16.0	24
450				10–24	71.0	35
100		at 10°	Petri dish	24, then	4.0	24
				10–24	70.0	35
		at 15°	Petri dish	24, then	0.0	24
				20–24	29.0	35
50	November 14	Air-dry, then moist peat April 30 (61 days) 5°	Petri dish	10–24	82.0	17
50	November 28	.....	Petri dish	10–24	88.0	17
			Petri dish	10–24	92.0	17
			Petri dish	10–24	99.5	17

TABLE XXII

GERMINATION OF SEEDS OF BERBERIS THUNBERGII PLANTED IN COLD FRAMES NOVEMBER 28

No. of seeds	Condition and date of collection	Inches of mulch	Date of removal	Percentage seedlings		° C.*
				May 9	May 26	
1000....	Seeds, November 12	0	.....	53.2	60.3	.....
700....	Berries, November 12	0	.....	53.9	81.3	.....
1000....	Seeds, November 28	0	.....	78.1	.....	.....
700....	Berries, November 28	0	.....	66.2	96.0	.....
1000....	Seeds, November 12	3		65.3	.....	3
700....	Berries, November 12	3	April 1 and	52.6	63.0	3
1000....	Seeds, November 28	3	12	58.4	.....	3
700....	Berries, November 28	3		50.4	57.7	3
1000....	Seeds, November 12	6		49.1	.....	3–5
700....	Berries, November 12	6	April 1 and	65.6	71.9	3–5
1000....	Seeds, November 28	6	12	55.0	.....	3–5
700....	Berries, November 28	6		85.6	.....	3–5

* Atmospheric minimum was −3° F.

germinate best in the unmulched beds, due probably to the influence of fluctuating temperatures, which become effective there sooner than where the mulch must be removed. However, the germination of *Berberis thunbergii* is rather quick, and therefore was fairly complete by the end of April when the temperature became higher. Seeds planted in the berries were retarded a week or two, but the results are not very significant, since the berries might contain either one or two seeds.

Damping off by *Pythium* was checked by Dr. C. R. ORTON, who applied a 0.25 per cent solution of uspulun to the rows of seedlings on May 5 and again on May 12.

Discussion

The seeds studied differ rather widely in type and in their requirements for germination, but have some characteristics in common. All three fruits have a pulpy outer layer which must be eliminated prior to storage; otherwise considerable or even total loss may result from bacterial and other fungal infection.

In every case cold moist storage favors germination more than dry storage. In *Berberis* the chief effect is probably due to retention of water to such a degree that the time required for germination does not need to include a period of preliminary imbibition.

Cornus seeds, during the long period of 90 to 130 days of cold moist storage, exhibit interesting changes in capacity to germinate, catalase activity, respiration, and chemical composition. Increased capacity for germination is accompanied by increased catalase activity, and an increase in starch, sucrose, and soluble protein, but by decreased respiration continuing until germination actually begins. At higher temperatures (above 15°) on the other hand, no increase in readily usable food materials was noted, catalase activity dropped rapidly to a point much below that for air-dry seeds, respiration remained fairly high, and the seeds did not after-ripen. HARRINGTON (**18**) notes an increase in respiration with increased dormancy at higher temperatures for the apple seed, and a decrease at lower temperatures. He suggested that there is probably an increase in acids and sugars at the lower temperatures.

One would conclude from these facts that after-ripening is rather closely tied up with respiration. At the higher temperatures

the readily oxidized food materials may be used in respiration as fast as they are formed, while at the lower temperatures, necessary for after-ripening, the reduced respiratory activity allows them to accumulate in sufficient quantities to initiate growth.

Any relation between catalase activity and respiration is more difficult to demonstrate. The catalase is evidently used up at higher temperatures, where the respiration rate remains high. However, exhaustion of the catalase supply in the presence of aerobic respiration products does not stimulate production of the enzyme, until catalase activity again keeps pace with respiration, as Mrs. RHINE (**37**) has suggested in an application of LOEW's theory to her results. At low temperatures the drop in respiration is abrupt, after which the rate remains constant, while the increase in catalase activity is as gradual and steady as the decrease at higher temperatures, suggesting an accumulation of the enzyme. As germination begins at the close of after-ripening, both respiration and catalase activity show marked acceleration, but on account of the great individual variation in *Cornus* seeds, any preliminary drop in catalase, as observed by Mrs. RHINE in the early stages of germination, might not be detectable.

SHERMAN (**39**) reports a similar rise in catalase activity during after-ripening of *Crataegus mollis* seeds, accompanied by a decline in respiration rate after the sixth or seventh day. Although catalase does seem to be closely related to vigor and capacity for high metabolic activity, it does not, at least in some cases, follow the respiratory curve or even seem to be related to it, either during after-ripening or during the storage of moist unafter-ripened seeds at unfavorable temperatures.

COLE (**6**), citing DIXON's work, suggests that catalase by destruction of H_2O_2 formed during oxidation conserves other oxidizing enzymes. Thus, he suggests, the almost universal distribution of catalase may be related to the conservation of oxidizing enzymes.

KINZEL (**25**), as the result of extensive investigations with seeds of numerous families, has arrived at the conclusion that the habitat of the parent plant is closely correlated with the germination behavior of the seeds. In connection with this hypothesis he has especially emphasized two factors, cold and light. The seeds of plants

from alpine habitats are especially prone, he believes, to require before germination one or more seasons of freezing through, because for generations such seeds have been exposed to the low winter temperatures of the alpine meadows. On the other hand, seeds of the same genera but of lowland species may require no cold season, or at most only a short one to prepare them for germination. One of the genera he particularly observed during his earlier studies (**24**) was *Sambucus*. He regards this as a "Frost-keimer," requiring two seasons of freezing for germination. The results reported in the body of this paper do not agree with KINZEL's conclusions. *Sambucus* seeds not only do not require freezing, but in some cases do not require even a short cold treatment at a temperature above freezing. The most important factor influencing their germination, unless they are in a state of imposed dormancy, seems to be a suitable alternation.

Furthermore, "Durchfrieren," which is taken to mean actual freezing of the seed, is not only unnecessary but even injurious. Dry seeds are apparently uninjured but are not after-ripened at freezing temperatures. Moisture is essential to after-ripening. Whenever imbibed seeds of the species studied are exposed to temperatures below freezing long enough to freeze through, killing results. Undercooling may occur in some cases, or the moisture content of the seed may be so low that total killing does not result when the sand or soil about the seed is frozen. Since the power of the seed colloids to hold water is tremendous, ice does not form in the seed unless a relatively high moisture content has been attained. However, after-ripening in seeds of *Cornus florida* is retarded as the temperature drops to 0° C. Even when ice formation does not occur, the lower temperature and lower moisture content are less favorable for after-ripening than a temperature nearly 5° above freezing accompanied by sufficient moisture.

PACK (**33**) reports similar results for *Juniperus* seeds. Although exposure to −5° C. was not sufficient to injure the ungerminated seeds, no forcing action was noticed. Seeds which were germinated were killed by a rather brief exposure to freezing.

As may be concluded from the data presented, and from the results reported by other workers, freezing is not necessary to break

the hard coats of stony seeds. In most cases the swelling seed exerts a pressure sufficient to burst the covering. In other cases the effects of alternate wetting and drying or weathering weakens the coat so that it may easily be broken. TUKEY (**41**) found that freezing soaked peach pits did not crack the coats, even when prolonged sufficiently to kill the seed.

Summary

1. Seeds of *Cornus florida* are dormant when the fruit is mature. This dormancy, which is caused by embryo and endosperm characters, cannot be broken by treatments with acids, ether, or ethylene.

2. A period of 100–130 days at 0°, 5°, or 10° C. is most effective for after-ripening, which may be defined as that change in the endosperm and embryo of the seed in consequence of which the seed is able to germinate at ordinary temperatures (15°–27°).

3. The changes apparent during after-ripening are increase in starch, sugar, and amino acids, with little or no change in fats, acidity, or phosphatides.

4. Germination consists of a rather sudden swelling of the embryo and endosperm, sufficient to break the stony coat followed by the elongation of the hypocotyl. The cotyledons remain within the endosperm, acting as haustoria (**43**) until all the food reserves are exhausted, after which they function as leaves.

5. After-ripening conditions of cold moist storage may be obtained in mixtures of seeds with sand or peat placed in refrigerators, by burying the containers, or by planting the seeds in beds mulched during the winter.

6. Under natural conditions germination occurs in the spring among those seeds which have lain throughout the winter in moist sheltered spots well covered with leaves.

7. Catalase activity parallels after-ripening very closely. It may be considered an indication of the direction of change, whether toward deeper dormancy or toward germination.

8. Catalase activity has also been used to detect dead seeds.

9. Respiration falls early in the period of exposure to low temperatures for after-ripening, and remains low until germination begins. At higher temperatures (above 15°) it remained constant and fairly high for the length of time tried (124 days).

10. Seeds of *Sambucus canadensis* may or may not be dormant when collected. If not dormant they will grow in 14–30 days at a daily temperature alternation of 10° for 17 hours and 27° for 7 hours or at a similar range of alternation. If dormant they require a period of 85–100 days at 0° or 5°, after which they will germinate on subjection to the necessary alternation, or at 0°–5° if left long enough.

11. Such seeds when once split grow very well at higher constant temperatures.

12. Exposure to higher temperatures under germinative conditions deepens the dormancy in seeds of both *Cornus florida* and *Sambucus canadensis*, as indicated by their failure to germinate and their drop in catalase content. Recovery may be brought about in each case by a period of 130–140 days at 5° C.

13. Seeds of *Berberis thunbergii* resemble those of *Sambucus* in that they require alternating temperatures for germination. They differ in that they require only a very short cold treatment or none at all for germination.

14. Seeds of either *Sambucus* or *Berberis thunbergii* planted out-of-doors in the autumn, protected from freezing, and exposed to the fluctuating temperatures of early spring, reach from 60 to 70 per cent germination.

15. Freezing in no case favors after-ripening, and always kills large numbers of imbibed seeds.

16. Storage in the pulp, especially in a moist condition, leads in all seeds studied to bacterial and other fungal infection, resulting in a high percentage of killing. This is particularly true for *Cornus florida*.

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DISSOLVED GASES IN WATERS OF SOME PUGET SOUND BOGS

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(with two figures)

Introduction

This paper reports data on the composition of dissolved gases occurring in fifteen different samples of bog water collected from four sphagnum bogs near Seattle, Washington, and the constituents of two samples of gas collected directly from one of these bogs. The discussion deals with the probable relation of the dissolved gases to the growth of plants in the bogs. Since the four bogs differ somewhat in their physical character and in their flora, a description of each bog is given.

Esperance Bog is situated near the southern boundary of Snohomish County, about four miles north of the city limits of Seattle, and nearly half a mile west of the new Pacific Highway. It has an area approximating five acres, including a small pond near the center. The bog is surrounded by low hills of glacial till, which, prior to logging operations of some years ago, were covered with a coniferous forest. Much of the surface of the bog is composed of living *Sphagnum*, and under this is several feet of dead *Sphagnum* only slightly disintegrated. The deeper layers consist of a very wet brown peat containing remains of marsh plants.

The plants constituting the present bog flora are mainly *Ledum groenlandicum*, *Kalmia polifolia*, *Oxycoccus oxycoccus*, *Drosera rotundifolia*, *Carex* sp., and *Eriophorum russeolum*. On most of the bog these plants are in the living *Sphagnum*, although in a few places the *Sphagnum* at the surface is dead. The forest growth consists mostly of *Tsuga heterophylla* and *Pinus monticola*. The former species is much more abundant and the trees are small, many of them being not more than 6 feet tall, while the latter are rather scarce, but some of its specimens reach a height of 20 feet. Both species show some seedlings. *Nymphaea polysepala* and *Brasenia schreberi* are abundant

on the margin of the pond surrounded by the bog. Bunches of the former are also found in the bog with *Sphagnum* and the other bog plants crowding closely around them. The bog is rapidly encroaching upon the pond, *Kalmia* being a conspicuous pioneer in the advance, often accompanied by *Oxycoccus*, and usually closely followed by *Sphagnum* and *Carex*. The entire bog is very wet, and there are many holes and natural ditches in which water stands at practically the level of the pond. Much of the bog, particularly near the pond, is still in the floating mat stage of succession. These data seem to indicate that the lake or pond formerly occupied a large part of the depression, and that much of the bog has been formed by the advance of the floating mat of vegetation upon the body of water.

Soundings to a depth of 25 feet, made with a Davis peat sampler, did not reach solid soil. At from 23 to 25 feet samples of well disintegrated brown peat were obtained. These contained fibers of marsh plants, apparently *Carex*, and some whitish material which contained diatoms. At depths from 3 to 23 feet the material is very soft, in many places having the consistency of a thick soup.

Sunnydale Bog is situated about four miles south of the city limits of Seattle, just east of the Des Moines Highway. Low hills of glacial till surround it on three sides, while on the south there is an elevation of just sufficient height to prevent drainage. The coniferous forest that covered the hills has been logged off. The bog has an area of 20 or more acres, and surrounds a small lake or pond situated near the east side, having an area of about one acre. The main portion of this bog has grown up to an elevation of a foot or two above the pond, and is much drier than Esperance Bog. The surface is largely composed of *Sphagnum*, but this is mostly dead, excepting near the pond and in a few places near the marginal ditch.

The bog is completely encircled by a natural marginal ditch of the usual type found around mature sphagnum bogs in the Puget Sound region. This ditch is over 150 feet wide in places, and is very wet even in midsummer. Water in the ditch has a depth of several feet in midwinter. The vegetation of the ditch consists in some places of an almost pure stand of *Spiraea douglasii*, in other places of a dense growth of *Carex* with some *Menyanthes trifoliata*, while in others, where there is less water, it consists largely of *Thuja plicata* and

Tsuga heterophylla with some *Pseudotsuga taxifolia*. In many places throughout the ditch there is considerable *Alnus oregona*, *Salix* sp., and *Pyrus rivularia*.

On the margin of the pond there is a dense growth of *Polygonum* sp., *Comarum palustre*, and *Nymphaea polysepala*. In some places the water under the leaves of *Nymphaea* is filled with a dense growth of *Riccia fluitans*, and in other places there is a good deal of *Utricularia vulgaris* and *Myriophyllum* sp. The pond is 27 feet in depth in the center and 18 feet near the eastern margin.

All of the bog plants found in Esperance Bog are also found in the Sunnydale Bog. In addition, *Dulichium arundinaceum* and *Juncus ensifolius* are common in the wetter portions near the pond, and *Typha latifolia* is found in a few places. *Nymphaea polysepala* is common in this bog, as in Esperance. In the younger portions of the bog near the pond, it grows vigorously in openings several feet in diameter, but the bunches are small and are almost crowded out by the bog association in the mature stages of the bog farther back from the pond.

Much of this bog has reached a rather mature stage, and has a coniferous forest succession of *Tsuga heterophylla* reaching a height of 25 feet, together with some *Thuja plicata* which is not as tall. Seedlings of both of these species are common. There are also occasional small trees of *Pseudotsuga taxifolia*.

Over fifty soundings have been made in this bog, and numerous samples have been taken. In many places west of the pond bottom was not reached at 31 feet, and a layer of whitish material containing diatoms was found at 27 feet. East of the pond, at hole no. 1, where analyses were made of the dissolved gases in the water, the bog is 31 feet deep and rests on blue clay mixed with coarse sand. In the northern portion of the bog, at hole no. 2, where other analyses for the dissolved gases were made, bottom was not reached at 31 feet. Gravel was encountered at 13–17 feet at several points southeast of the pond. The surface as well as the deeper layers of this bog is very similar to that of Esperance.

White Center Bog has an area of less than 10 acres, and is situated about a mile west of White Center, just south of the city limits of Seattle. The bog lies in a north and south valley, and hills of gla-

cial till rise rather abruptly from it on the east and west. North and south of the bog the land is flat, and has an elevation just sufficient to prevent drainage. The coniferous forest that once surrounded the bog has mostly been removed, while a road has been graded along the southern side, covering a part of the marginal ditch. There is no pond in this bog. The surface is fairly dry in summer, but water stands on portions of it in winter.

The flora of this bog differs somewhat from that of the other three bogs described. There is very little *Sphagnum* on the surface, either living or dead, and no *Kalmia* or *Drosera* has been found. *Ledum* and *Oxycoccus* are abundant, and in places there is a dense growth of *Spiraea* and considerable *Carex*. Young trees of *Tsuga heterophylla* up to 8 or 10 feet in height are numerous, and *Thuja plicata*, mostly of a shorter height, are common. A few small specimens of *Pseudotsuga taxifolia* are also found. The usual marginal ditch surrounds the bog.

Three soundings were made in different parts of the bog, and blue clay was found at depths of 14 feet in all cases. A hole 4 feet in depth was dug in the bog in June, when the water table was low enough to permit such digging without encountering much water. The upper 6 inches was found to consist of fibrous peat with no *Sphagnum*. The next 12 inches was pure *Sphagnum* only slightly disintegrated. The peat below that was uniform in character. It was dark brown, and the remains of a *Carex*-like plant were abundant in it.

Ronald Bog has an area of more than 20 acres, and is situated about 3 miles north of the city limits of Seattle and one-half mile east of Ronald station. It is surrounded by low hills of glacial till and there is no drainage from it. The coniferous forest that covered the hills has been cleared and several ranches now occupy portions of the land adjacent to the bog. An automobile road crosses the northern end of the bog on a fill, and portions of the marginal ditch have been used as a dumping ground for refuse. On the eastern boundary the marginal ditch widens into a rather extensive marsh, characterized mostly by dense growth of *Spiraea douglasii*, with a quantity of *Populus tremuloides* reaching a height of 15 feet.

The bog has the usual flora of *Ledum groenlandicum*, *Kalmia*

polifolia, *Oxycoccus oxycoccus*, and *Drosera rotundifolia*. There is still some living *Sphagnum*, although this has grown less and less as the bog has dried out through its modification by human agencies during the last 15 years, and much of the surface now consists of dead *Sphagnum*.

The forest growth in this bog consists mostly of *Pinus monticola*. Trees of this species are numerous, and commonly reach a height of 30–35 feet in the older portions of the bog. There is also considerable *Tsuga heterophylla*. Seedlings of both of these species are common. A few small specimens of *Pseudotsuga taxifolia* are found. Good trees of *Picea sitchensis* were common in the marginal ditch prior to clearing, but none were found in the bog itself.

The upper layer of the bog to a depth of 2 feet or more consists of *Sphagnum* in a good state of preservation and brown in color. Below this is brown peat free from *Sphagnum*, but containing remains of a *Carex*-like plant and some fragments of woody plants. Eight soundings were made on a north and south line in the central portion of the bog, but not extending to the marginal ditch. Sand was reached at 7 feet in the most northerly sounding, and at gradually increasing depths up to 17 feet for the sixth sounding. Blue clay was reached in the seventh sounding at a depth of 26 feet, and in the eighth at 27 feet. The peat is less watery than that of Esperance Bog and Sunnydale Bog, but slightly more watery than in White Center Bog.

Collection of samples

Holes about 2 feet in diameter were dug in the bog, and collections were made from the water that seeped into them from the substratum. In Esperance Bog these holes were about 2.5 feet deep and they were filled with water in 15 minutes. In other bogs deeper holes were dug, 4 feet in Ronald Bog being the deepest, and water accumulated in them much slower, a wait of an hour being necessary in many cases.

In securing samples of bog water, a 2.5 liter glass-stoppered bottle was used, loose pieces of *Sphagnum* and other plant remains being prevented from entering the bottle by means of wire gauze. The stopper was replaced in the bottle while it was submerged, and on being brought to the surface it was thoroughly sealed. The bottle was then

TABLE I

QUANTITIES OF VARIOUS GASES DISSOLVED IN BOG WATERS

DESCRIPTION OF SAMPLE	DATE COLLECTED	GAS DISSOLVED PER LITER OF WATER ML. CORRECTED TO 760 MM. 0°C.	CARBON DIOXIDE			OXYGEN			METHANE			NITROGEN		
			Per cent by volume	p.p.m.	ml. per liter	Per cent by volume	p.p.m.	ml. per liter	Per cent by volume	p.p.m.	ml. per liter	Per cent by volume	p.p.m.	ml. per liter
Esperance Bog														
Hole 1.....	Oct. 31, 1925	64.4	60.4	76.9	39.2	0.0	0.0	.....	22.3	10.3	14.4	17.3	13.9	11.1
Hole 2.....	Nov. 25, 1925	58.5	62.2	71.9	36.7	0.3	0.3	0.2	9.4	3.9	5.5	28.1	20.6	16.5
Hole 3.....	Feb. 27, 1926	60.6	57.0	68.3	34.8	0.0	0.0	.....	21.5	9.3	13.1	21.5	16.3	13.1
Sunnydale Bog														
Hole 1, sample 1...	Feb. 27, 1926	59.9	60.4	71.5	36.5	1.1	0.9	0.6	11.6	5.0	7.0	27.0	20.2	16.2
sample 2...	Feb. 27, 1926	59.5	61.0	71.7	36.6	1.1	0.9	0.6	9.7	4.1	5.7	28.2	21.0	16.8
Hole 2, sample 1...	Feb. 27, 1926	45.4	44.2	39.7	20.3	1.9	1.2	0.8	17.3	5.6	7.9	36.6	20.8	16.6
sample 2...	Feb. 27, 1926	46.5	43.9	40.4	20.6	2.0	1.3	0.9	17.6	5.9	8.3	36.5	21.2	17.0
White Center Bog														
Hole 1, sample 1...	Nov. 25, 1925	38.9	46.5	35.8	18.3	2.7	1.5	1.1	0.0	0.0	.....	50.8	24.7	19.8
sample 2...	Nov. 25, 1925	39.2	47.3	36.7	18.7	3.2	1.8	1.3	0.0	0.0	.....	49.5	24.3	19.7
Hole 2, sample 1...	Feb. 27, 1926	35.2	46.6	32.4	16.5	0.0	0.0	.....	0.0	0.0	.....	53.4	23.5	18.8
sample 2...	Feb. 27, 1926	35.1	46.6	32.3	16.5	0.0	0.0	.....	0.0	0.0	.....	53.4	23.5	18.8
Ronald Bog														
Hole 1, sample 1...	Feb. 27, 1926	35.1	47.7	33.1	16.9	0.2	0.1	0.1	0.0	0.0	.....	52.1	22.9	18.3
sample 2...	Feb. 27, 1926	37.1	47.1	34.5	17.6	0.0	0.0	0.0	0.0	0.0	.....	52.9	24.5	19.7
Hole 2, sample 1...	Feb. 27, 1926	48.5	58.2	55.8	28.5	1.1	0.8	0.6	0.0	0.0	.....	40.7	24.7	19.8
sample 2...	Feb. 27, 1926	48.9	57.6	55.7	28.5	0.9	0.6	0.4	0.0	0.0	.....	41.5	25.4	20.3

taken immediately to the laboratory and stored in a refrigerator until preparations were complete for analysis.

The gas from Esperance Bog was collected by immersing and inverting the top of a large funnel, 30 cm. in diameter, in the water that had accumulated in the holes. The funnel was connected with a gas sampling bottle by means of rubber tubing and the entire apparatus completely filled with the water. A long pole was then run into the soft peat at the bottom of the hole and worked back and forth until sufficient gas was collected.

Holes no. 1 and no. 3, table I, in Esperance Bog were in a later stage of bog succession. Hole no. 2 in this bog was nearer the pond in a much earlier stage of the succession. Hole no. 1 in Sunnydale Bog

TABLE II

ANALYSES OF GASES COLLECTED FROM ESPERANCE BOG

SAMPLE NO.	PERCENTAGE					
	Carbon dioxide	Oxygen	Carbon monoxide	Unsaturated hydrocarbons	Methane	Nitrogen
1.....	3.8	0.0	0.0	0.0	30.6	65.6
2.....	4.0	0.0	0.0	0.0	37.4	58.6

was west of the pond and in an earlier stage of the succession than hole no. 2, which was located in the northeast portion of the bog. The two holes in Ronald Bog were 100 feet apart, but were practically in the same stage of the succession. In White Center Bog hole no. 1 was near the marginal ditch, while hole no. 2 was near the center of the bog.

The two samples of bog gas, the analyses of which are shown in table II, were collected from the same hole in Esperance Bog (no. 1). Sample no 1 was collected first, and represents the gases accumulated in the upper strata of the bog, while no. 2 was obtained by disturbing the peat at greater depths.

In all cases the temperature of the water at the time of collection of samples in any of the bogs was never above 10° C. or below 4° C.

Apparatus used

After a study of the literature dealing with the analysis of gases dissolved in natural waters, a modification of the method described

by TREADWELL and HALL[1] was finally utilized. Fig. 1 shows the modified type of apparatus employed in this investigation, while a description of its manipulation is outlined below.

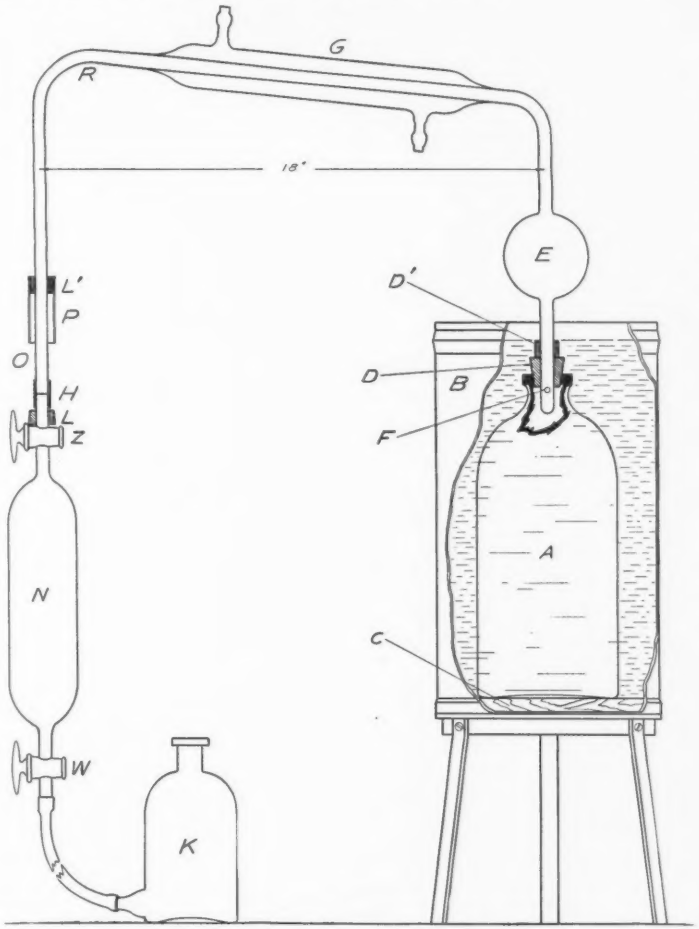

FIG. 1

The bottle *A*, containing about 2.5 liters of the bog water to be analyzed, was placed in the boiler *B*, so that it rested upon the wood-

[1] TREADWELL and HALL, Analytical chemistry. Vol. II, 630–632. 6th ed.

en stand *C*. The employment of the latter was necessary as it insured proper circulation of the heating medium of the boiler. This prevented cracking the container by sudden temperature changes, and eliminated the undesirable effects of violent bumping. The bulb *E*, together with the two pieces of tubing sealed into it, were made of pyrex glass and are partly illustrated in detail in fig. 2. One stem of the bulb, sealed at the end but having a hole of sufficient size at *F*, was adjusted to position no. 1 (fig. 2) and immersed in distilled wa-

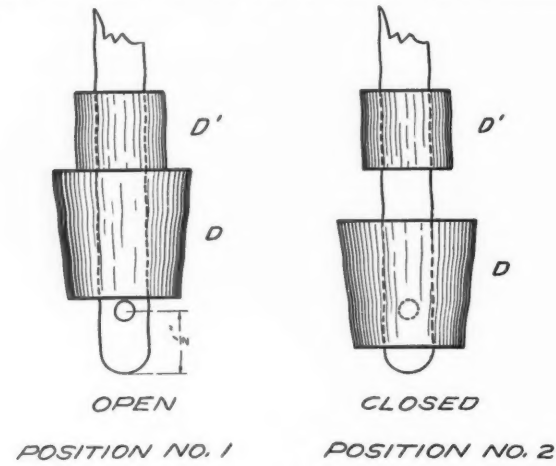

FIG. 2

ter. A rubber stopper (*D*) served to regulate the proper adjustment of the hole (*F*). A suction was applied at the end of the stem *O*, and water drawn into the bulb (*E*) until it was half filled. The hole was then adjusted to position no. 2 (fig. 2). Heat from a Bunsen burner was applied at *E* to thoroughly boil the water in the bulb. During this process the condenser (*G*) was free of any water that might have served as a cooling agent. Boiling was continued for at least five minutes, in order to expel all the air from the tube *O*.

The services of two persons were required to connect the various pieces of apparatus. One held the piece containing the bulb with its pyrex tubing and condenser and kept the water in the bulb boiling vigorously, while the other made the proper connection at *H* with

gas holder *N*, by means of heavy-walled rubber tubing. The latter was carefully wired. The small glass tube *P* was lowered from the rubber stopper *L'* to *L*, and filled with water or mercury, thus giving a water or mercury seal to the connection. The entire process of connecting and sealing was performed in less than a minute. When complete, the source of heat at *E* was withdrawn.

The glass stopper of the container was then removed, and the space occupied by it filled with distilled water. The rubber stopper (*D*) was inserted into the bottle. The boiler was then filled with a saturated sodium chloride solution so as to immerse completely the rubber stopper. This gave a water seal to the connection. The small stem of the bulb was adjusted to position no. 1 (fig. 2), and the connection made with *D* was tightened and secured with wire. The hole *F*, in position no. 1, was arranged so that it was just below the stopper. This was very essential as it eventually permitted the complete removal of the gases from the bottle as they came out of solution.

The temperature of the solution in the boiler was raised and so regulated that the water in the container was kept boiling. The usual device for maintaining a constant level was attached to the boiler.

Water was permitted to circulate through the condenser as soon as the heat was applied to the boiler. At the same time the stopcocks *Z* and *W* were opened, and the mercury, which had completely filled the gas holder *N* and the small tube projecting from it at *H*, flowed into the reservoir (*K*). A partial vacuum was thus produced in the system, and any tendencies for leaks at *H* and *D* could easily be noted and rectified.

The bog water in the container *A* was subjected to boiling temperature for at least an hour and until all dissolved gases had been removed. As the result of heating the 2.5 liters of bog water, an expansion of about 90 ml. was obtained. The bulb (*E*), which had a capacity of 200 ml., readily accommodated the excess water, and also provided ample space into which large bubbles from the container burst without being carried over to the gas holder *N*. The water condensing in the tube contained in the condenser ran back into the bulb.

After the gases had been completely boiled off, the solution in the boiler was cooled sufficiently so as to permit the removal of the stopper. Care was taken that the hole was kept well below the sur-

face of the water in the boiler. The water in the bulb was boiled for a minute to insure the removal of any dissolved gases. All of the gas in the tube (*O*) was then rapidly drawn into the container *N*.

The method, while somewhat tedious, yielded excellent results after sufficient skill had been acquired in the manipulation of the apparatus. Care was exercised in removing all the air from the tube (*O*), the bulb (*E*), and its complete displacement by mercury in all parts of the gas holder *N*. When the connection was made at *H* a towel was wrapped around the gas holder, which protected it from the steam and an occasional drop of hot water. Wiring of the rubber tubing at *H* and of the stopper *D* was found to be important, and the use of the water and mercury seals essential. In transferring the residual gas in the tube *O*, the amount of water entering the gas holder was kept at a minimum by the following manipulation. The water was drawn through the tube until it reached the bend at *R*. Stop cock *Z* was closed, and then the pressure of the gas in the container greatly reduced. The stop cock was then opened again and closed just as soon as all of the gas in the tube was transferred.

Methods of analysis

The total volume of the gas obtained from the samples of water was measured. The necessary corrections for temperature, pressure, and water vapor were made, and the amount of gas, calculated for standard conditions, dissolved in a liter of the water was determined. Portions of the gas were carefully analyzed in the usual manner for carbon dioxide, oxygen, carbon monoxide, unsaturated hydrocarbons, and methane. The residual gas was reported as nitrogen. Hempel burets and pipets were utilized.

Discussion

The outstanding facts shown in tables I and II are: (1) The considerable quantities of methane in the samples of water from each bog containing a lake or pond, and its absence in bogs not containing such open bodies of water. The former type of bog is designated here as a "wet bog," while the term "dry bog" refers to one of the latter type. (2) The relatively large amounts of carbon dioxide found in all of the samples of bog water. (3) The presence of greater quantities of carbon dioxide in the wet bogs than in the dry bogs. (4) The en-

tire absence of oxygen in five of the samples and the presence of only very small amounts in the other ten. (5) The complete absence of carbon monoxide and unsaturated hydrocarbons in all of the waters. (6) The greater quantities of dissolved gases in the waters of wet bogs than in those from dry bogs. (7) The large amount of dissolved nitrogen (residual gas) in samples from dry bogs as compared with that in the wet bogs. (8) The greater concentration of methane in the deeper layers of Esperance Bog as compared with the more superficial layers. (9) The small amount of carbon dioxide and the large amount of methane in the gas samples collected by agitation of the sphagnum peat under the waters in Esperance Bog.

The injury to many land plants by submergence of their roots in water is well known. Plants that ordinarily grow in soil that is merely moist are usually killed by such treatment, although plants that flourish in very wet habitats will stand rather prolonged submergence of their roots. BERGMAN[2] showed this by experiment, and his results agree with the observations of the writers on agricultural plants where submergence by the overflow of streams occurred. This is also in accordance with their observations on native plants growing in low places in the Puget Sound region, where flooding in winter and spring was frequent.

The four bogs discussed in this paper differ considerably in the level of the water table at different seasons. In Esperance Bog the water table is practically at the surface during the entire year. *Carex* flourishes in the bog stage here, but other plants that ordinarily grow in marshes have not established themselves. *Nymphaea*, which flourishes in the pond, remains in the early bog stage but not in the later. *Brasenia* is abundant in the pond but is not found in the bog. In Sunnydale Bog the conditions in regard to the water table close to the pond are similar to those in Esperance Bog, but farther back, where the bog stage is more mature, the water table is low enough in summer so that the roots of plants growing there are not submerged. *Nymphaea* behaves in the same manner in this bog as it does in Esperance Bog. *Dulichium arundinaceum* and *Typha latifolia*, whose roots are well known to withstand considerable submergence, flourish in the earlier stages of this bog, where the water table is high.

[2] Ann. Botany 34:13–33. 1920.

Land plants have only in rare instances established themselves, however, even where the water table is low.

In Ronald Bog the water table is low enough so that the roots of plants are not submerged in spring and summer, yet land plants, with the exception of *Pteridium aquilinum*, have not established themselves, in spite of the fact that the bog has become much drier by the clearing of the surrounding forest. White Center Bog is flooded in winter, but the water table is lowered considerably in summer. It lacks some of the usual bog plants, while *Spiraea douglasii*, a marsh plant, is abundant. It is to be remembered that the surface layer of peat in this bog is not sphagnum peat, although the second layer is composed of this material. Evidently the stage of succession must be considered as a factor in this bog.

However, the growing season in the Puget Sound region is long, and the roots of many plants grow considerably, even in the winter months. Flooding at this time and in the spring may have greater effects upon bog flora of this region than in places where roots are dormant for a longer time. While the occurrence of certain plants in the four bogs and the absence of other plants growing in the immediate vicinity correlate to a certain extent with submergence of roots, they do not entirely do so, and other factors must be considered.

The necessity of an oxygen supply around the roots of plants and the injurious effects of large amounts of carbon dioxide are well established. BERGMAN found that potted plants are injured or killed by replacing the soil atmosphere with carbon dioxide, and that injury to plants by submergence in many cases is obviated by aeration of the water. CANNON[3] carried out experiments on root growth in relation to a deficiency of oxygen and an excess of carbon dioxide in about 30 species, including a number of agricultural plants. The data on carbon dioxide in the substratum of Puget Sound bogs are not directly comparable with CANNON'S results. The analyses shown in table I give the percentage of carbon dioxide found in the gas dissolved in the waters, while he used it as a soil atmosphere. The difficulty of conceiving how carbon dioxide can be so injurious to the growth of the roots of land plants, as is shown in CANNON'S results, and not be likewise injurious to them when dissolved in the

[3] Carnegie Inst. Wash. Publ. 368. 1925.

soil water, is removed by a consideration of the following equilibrium conditions between the carbon dioxide and the soil water: $CO_2 \rightleftarrows CO_2+H_2O \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^-$. While a portion (gas) (dissolved gas) of the carbon dioxide is in solution, it is evident that a relatively large portion has reacted with the water, forming an entirely different substance. This is particularly true of soil solutions where a degree of saturation is by no means approached. The formation of the acid gives rise to the factor of acidity, which may have a decided effect upon the growth of roots. Furthermore, an increase in carbon dioxide reduces the partial pressure of oxygen, and thus decreases the solubility of the latter gas.

BERGMAN has determined the amount of carbon dioxide in the waters of a lake, a swamp, and a bog in Minnesota. Water was taken from under the *Carex-Calamagrostis* "associes" and the *Larix-Picea* "associes" in the swamp bordering a lake. *Sphagnum* and other mosses were abundant in both "associes," and under *Carex* and also under *Andromeda* and *Sphagnum* in the bog. The amount found by BERGMAN for the Minnesota bog varies from 11.4 to 20.1 p.p.m., average of all results being 15.1 p.p.m., while the amount found by the writers in Puget Sound bogs varies from 32.3 to 76.9 p.p.m., average of all being 50.4 p.p.m. Some of the latter results are in accord with those reported by ENDELL[4] for European bogs. BERGMAN implies that his field determinations were not exact, and it seems probable from statements made in his paper that all of the gases were not removed from the solutions analyzed in the laboratory. The amount of carbon dioxide found in the Puget Sound bogs is over 325 per cent greater than that found in the Minnesota bogs. This difference may have been caused by seasonal variations, higher temperatures of the Minnesota water, greater light penetration, and differences in regional flora conditions. In agreement with the writer's observations are those showing increases from the *Carex* stage to the *Chamaedaphne-Andromeda* and the *Larix-Picea* stages, and a further increase from these stages to that of the bog.

Since oxygen was entirely absent from the dissolved gases in five of the Puget Sound samples, and the maximum amount occurring in the other ten was only 3.2 per cent of the total gas dissolved, it would

[4] Jour. Prakt. Chemie. 82:414–422. 1910.

seem that oxygen deficiency must present serious difficulties. The growth of roots of any ordinary land plants, whose seeds might in any way be carried into the bog, or whose vegetative parts might begin to grow forward into the bog from any bordering association, would be either greatly retarded or entirely prevented.

The presence of methane in bogs that have developed by forming a floating mat on open bodies of water correlates with the well known fact that large amounts of methane are produced by the decay of masses of organic matter at some depth in undisturbed waters. It seems to follow naturally that the amount of methane would be greater in the deeper layers than in the upper, due to its formation and solubility. The presence of the methane decreases the partial pressure of the other gases, and thus reduces their solubilities. This is shown by the smaller amount of nitrogen, the least soluble of the gases, dissolved in the waters of the wet bogs, and by the high concentration of nitrogen in the gases liberated in Esperance Bog. The presence of methane may also correlate with the earlier stage of development found in the wet bogs. No work on the effects of this gas on the growth of roots has come to the attention of the writers.

Summary

1. The differentiation between wet bogs and dry bogs appears to be characterized by the gases dissolved in the waters of the bogs.

2. Wet bogs contain methane while dry bogs do not.

3. Wet bogs contain greater concentrations of carbonic acid than the dry bogs.

4. The presence of methane causes the liberation of nitrogen from solution, and thus wet bogs contain smaller dissolved quantities of this gas.

5. The oxygen content in all samples of bog water examined is practically nil. This marked oxygen deficiency when viewed in the light of the effects of such conditions on ordinary land plants, found by other workers, leads to the inference that this condition must be a large factor in the inhibition of non-bog plants from bogs of the Puget Sound region, and that bog plants are more tolerant of these conditions.

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DEVELOPMENT OF OVULE AND EMBRYO SAC OF COCOS NUCIFERA[1]

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(WITH THIRTEEN FIGURES)

Introduction

It seems strange that a plant so interesting and economically important as the coco palm has received so little attention morphologically. Our knowledge of the morphology is fragmentary and limited. The agronomy of the coco palm has been studied extensively; and lately the development of the inflorescence, the female flower, and the stony layer has been investigated (**15**). The present paper is intended to give only a description of the development of the ovule and the embryo sac at the time of fertilization, and later it is hoped to give a full account of fertilization and the development of the endosperm and embryo.

While, as might be expected, the results of this study do not show wide deviation from the usual series of events in monocotyledons, they have value in indicating the extent of variation within a given order. RADERMACHER (**18**), studying *Nipa fruticans*, found that the archesporial cell functions directly as the embryo sac mother cell, which divides into a "dyade." The chalazal cell enlarges and becomes the macrospore of the sac. The mature embryo sac possesses eight nuclei. This writer also investigated *Actinophloeus macarthurii* (*Ptychosperma macarthurii* H. Wendl.), and although his series is incomplete, found that the embryo sac mother cell is deep seated, with eight nuclei.

BAUCH (**1**) observed the 2-nucleate embryo sac of *Phoenix* with three complete degenerated cells as remains of the tetrad cells. According to this investigator *Licuala* has an 8-nucleate embryo sac, and *Sabal* and *Zalacza* possess a widened one. The development of the embryo sac of *Dypsis*, which is 8-nucleate, is similar to that of

[1] College of Agriculture, University of the Philippines, Experiment Station Contribution, no. 459.

Calyptrocalyx. He also saw the embryo sac of *Heterospathe*. *Nephrosperma* and *Verschaffeltia* have antipodals which remain long in the sac as an inward prominence of the nucellus. *Ptychococcus* and *Areca* show the remains of the tetrads in their embryo sacs, the former possessing only two, the latter three. BAUCH[2] states:

> The embryo sac mother cell is formed in the first and second row of cells of the nucellus. There may be also formed two embryo sac mother cells, but only one develops, the other degenerates. In *Cocos*, also, the remnants of the tetrahedral cells, which are located near the micropyle, are evident. It is therefore apparent that the cell which is near the chalazal develops into the primary embryo sac mother cell.

So far as the writers know, no work on the ovule or embryo sac of *Cocos nucifera*, except that of BAUCH cited by RADERMACHER (18), is on record.

Material and methods

The material used in this study was gathered between March and April, 1925, from twenty trees growing in the Bacomo Coconut Plantation of the College of Agriculture, University of the Philippines. Two of the trees were killed, and all unopened spadices in which the female flowers could be differentiated by the unaided eye were fixed. Twelve inflorescences were selected, and their dates of opening carefully noted. Inflorescences were gathered at intervals of 3, 4, 6, 9, 12, 15, 19, and 22 days respectively after they opened, until the stigmas were exposed. All female flowers from the inflorescences were then fixed. Slabs were cut from the two sides of the younger pistils and from the four sides of the older ones, and then fixed *in toto* with their perianth segments on or removed.

Only formo-aceto-alcohol (4) and formo-alcohol were used to kill and fix. After fixing the material was washed in 70 per cent alcohol, dehydrated by passing through successive grades of alcohol, dealcoholized in several ascending series of xylols, imbedded in paraffin, and cut with the Spencer rotary microtome into sections 5–7 μ. The appearance of large vacuoles in the sac and the presence of tannin idioblasts in the pericarp made cutting the material rather difficult. Flemming's triple stain was used in some cases. Haidenhain's iron-alum with Orange Gold dissolved in clove oil as background was used throughout, and proved to be very satisfactory.

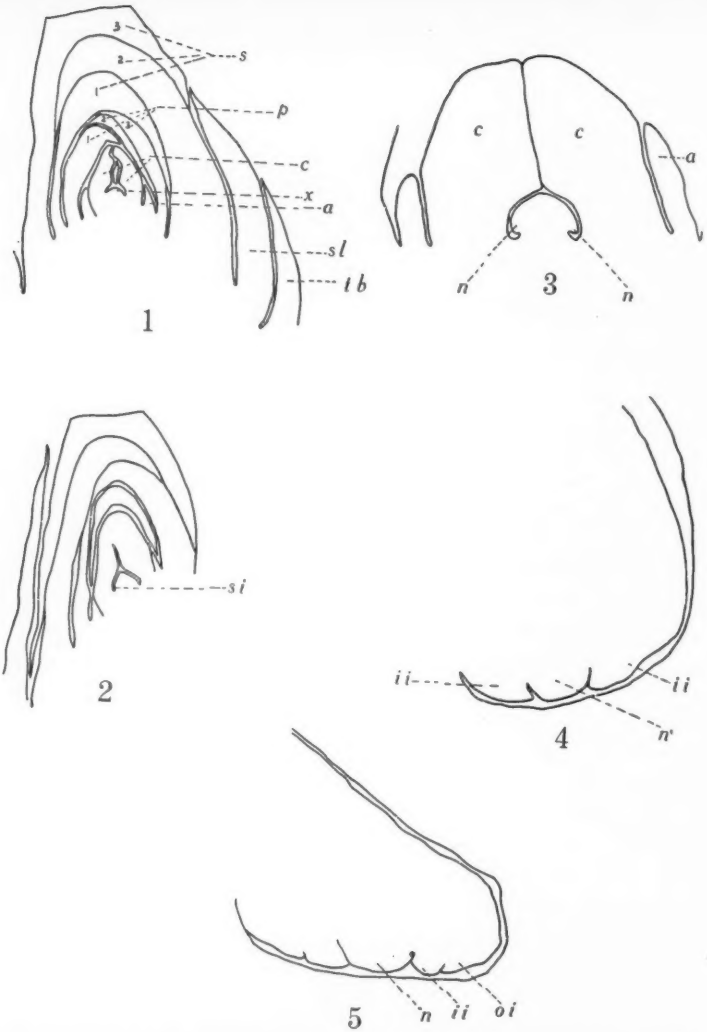
[2] Cited by RADERMACHER; original article of BAUCH not procurable.

Ovule

The development of the spadix and the floral segments of the female flower has been investigated (15). The centripetal appearance of the floral organs is as follows: (1) scaly leaves or "braceteoles," (2) sepals, (3) petals, (4) aril, and (5) carpels. When all the floral envelops and carpel walls have been formed and differentiated, the main axis of the flower starts as a papilla and commences to enlarge, gradually becoming prominent at the basal portion of the ovarial cavity (fig. 1). This protuberance consists of an epidermal layer of cells, most of which are squarish to rectangular, with their long axes tangential to the periphery. The hypodermal cells are isodiametric, filled with plenty of protoplasm and large nuclei. Their growth keeps pace with that of the carpel walls. As the main axis enlarges, the epidermal and hypodermal cells divide and elongate periclinally, and their cytoplasmic contents become less thick than those at the side. This gives the axis a pyramidal appearance (fig. 2). Simultaneously with the elongation of the cells at the apex, the basal cells at the sides (*s*) divide periclinally at first, and division rather than elongation is their first activity. By repeated periclinal divisions of the cells at the sides, and radial elongation and enlargement of the cells at the apex of the axis of the flower, the basal lateral sides are pushed into the three loculi of the carpel walls. These protuberances, which at first are slight, constitute the nucellus (fig. 3*n*) of the ovules. By one-sided growth each primordium becomes bent toward the base of the ovary, developing into the anatropous ovules. It is interesting to note, however, that in the coco palm the usual development of the anatropous ovules as shown in *Lilium philaselphicum* (7) is not closely followed. The nucellus appears first as a few-celled papilla, with projections from which the integuments develop (figs. 4, 5).

The hypodermal cells of the nucellus then divide periclinally and anticlinally. The activity of that mass of tissue is responsible for the enlargement of the nucellus, rather than the epidermal. The epidermal cells remain squarish and become comparatively smaller than the hypodermal cells, which in their juvenile stages are nearly identical in size. Anticlinal division of the epidermal cells enables it to keep pace with the increasing nucellar tissue.

The integuments do not begin to appear until after the inflorescence has attained a maximum circumference of 15–18 cm. (meas-



FIGS. 1–5.*—Fig. 1, median longitudinal section of female flower showing tertiary bract (*tb*), scaly leaves or "bracteoles" (*sl*), sepals (*s*), petals (*p*), aril (*a*), carpels (*c*), and floral axis (*x*); ×11.5. Fig. 2, median longitudinal section of older flower showing pyramidal appearance of floral axis; *si*, sides of axis where nucellus of ovule is developed; ×11.5. Fig. 3, median longitudinal section of ovary showing beginnings of nucellus (*n*) of ovules, within carpel walls (*c*); ×53. Fig. 4, longitudinal section of anatropous ovule with inner integument (*ii*) already developed; ×235. Fig. 5, longitudinal section of much older ovule with two integuments, inner (*ii*) and outer (*oi*), appearance of latter being belated; ×235.

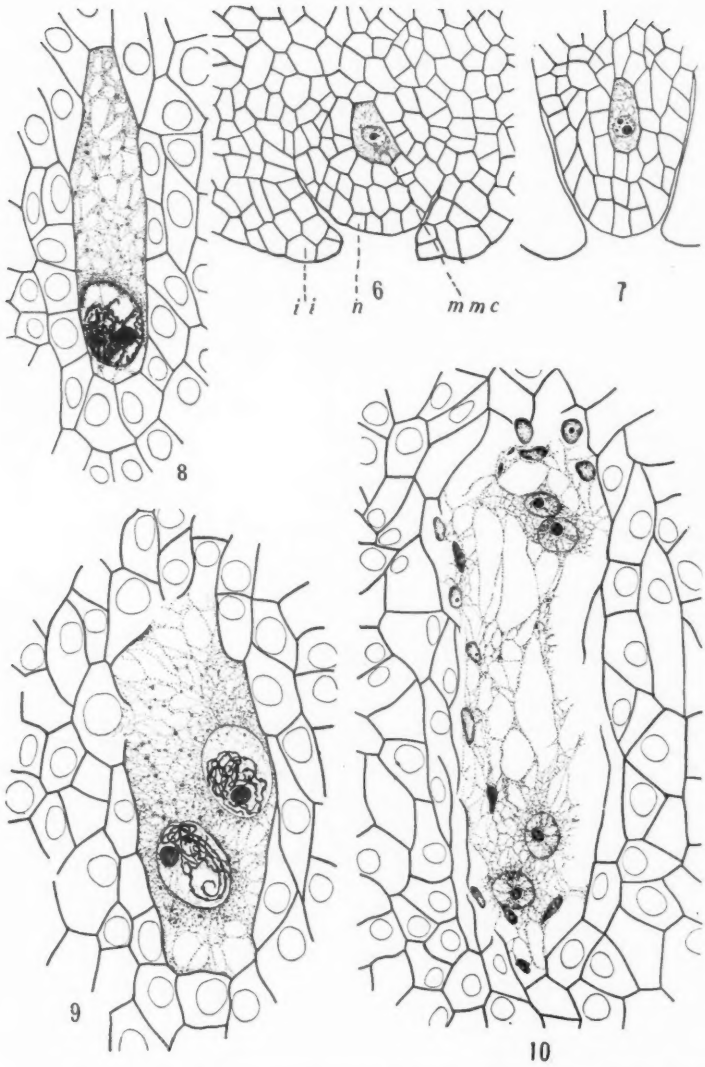
* All drawings were made with the Spencer microscope, Bausch and Lomb lucida, bar length 110, and the mirror at an angle of 55°.

ured with the inner spathe still attached). The inner integument (fig. 4) is the first to develop, followed by the outer (fig. 5).

Embryo sac

The ovule attains a considerable size, with its integuments fully differentiated before the archesporial cell becomes evident. The archesporial cell becomes the megaspore mother cell, and enters synapsis after the two integuments have long been evident. At first the megaspore mother cell is apparently undifferentiated from the surrounding cells, but soon it becomes grumous and is then readily distinguishable (figs. 6, 7). It can easily be recognized from the rest of the nucellar tissue by its size and great staining power. The presence of a large nucleus and its richness in cytoplasm make the megaspore mother cell more prominent. The megaspore mother cell is apparent after the inflorescence has emerged from the outer spathe, and while still enveloped by the inner spathe. It is more or less squarish, with the nucleus at the center of the embryo sac (fig. 6) to begin with, but soon elongates with its micropylar portion enlarged (fig. 7). The mother cell usually appears at the third layer of cells of the nucellar tip, but may sometimes be deep seated at the fourth or fifth layer. As the cell enlarges and elongates, there seems to be a definite migration of the nucleus to the micropylar end. Vacuolation of the one-celled embryo sac becomes apparent and progresses as the sac enlarges. The cytoplasm is denser toward the micropylar portion of the cell and vacuolated at the chalazal region. The writers have failed to find more than one archesporial cell developing, but BAUCH maintains that he found two, only one of which became functional.

The archesporial cell elongates and increases in size, always maintaining the bulbous and bulging appearance, wider at the micropylar end, with the chalazal end somewhat narrow. More granular bodies seem to accompany the enlargement of the nucleus. The vacuoles enlarge in the nucleus, and granular bodies appear in the network of protoplasm. Later, within the nuclear membrane a network of fine dotted threads is partially meshed by granular substance. The first stage which can be identified as indicating approaching division is the slender spireme (fig. 8). The threads become thicker and their dots larger, the nucleolus still remaining prominent. Before



FIGS. 6–10.—Fig. 6, longitudinal section of ovule with archesporial cell already differentiated, which functions as megaspore mother cell (*mmc*); ×540. Fig. 7, megaspore mother cell beginning to elongate; ×540. Fig. 8, megaspore mother cell at synaptic stage; ×890. Fig. 9, dinucleate stage of embryo sac; daughter nuclei at synaptic stage; note absorption of nucellar tissue beginning at chalazal end; ×890. Fig. 10, quadrinucleate stage of embryo sac, two nuclei at micropylar end and two at chalazal end; note destruction of nucellar tissue; ×890.

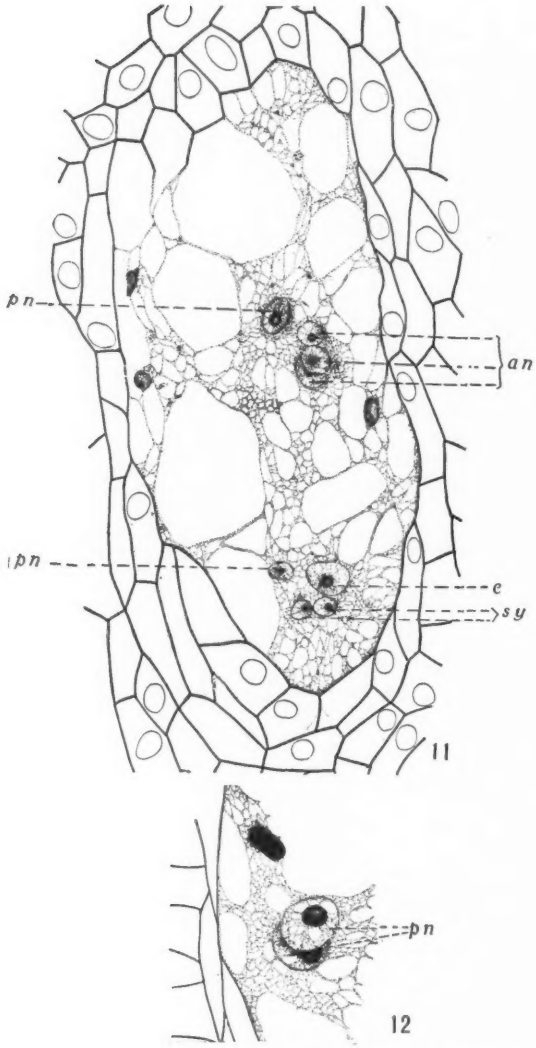
finally passing into the contracted state, the ribbon just described begins to close round the nucleolus. The nucleus now enters the period of synapsis, in which it remains for some time.

The nucleus of the megaspore mother cell of the embryo sac next divides into two, more or less unequal in size, without wall formation (fig. 9). This takes place before the emergence of the inflorescence from the envelope of the inner spathe. In the coco palm the formation of the tapetal cell and the four megaspores is eliminated, the two daughter nuclei lying side by side. They are vacuolated, and in the early synaptic stage of division. More granules are present in the cytoplasm of the sac. At this stage the sac shows signs of disintegration and absorption of the nucellar cells, which begins at the chalazal region (figs. 9, 10). Since the formation of the tetrad is eliminated, this first division of the megaspore mother cell must be heterotypic in nature. In the first division of the megaspore mother cell it was not possible to count the number of chromosomes.

At the binucleate stage of the sac no polarity is evident. Vacuolation begins at the micropylar and chalazal ends, and the daughter nuclei are at the center of the sac. Both chalazal nucleus and micropylar nucleus are commonly similar in shape and age, although the chalazal nucleus seems more advanced in development (fig. 9).

At the quadrinucleate stage of the sac polarity is in full display (fig. 10). The four daughter nuclei are at the ends of the sac, two at the micropylar and two at the chalazal end, the micropylar nuclei being larger than the chalazal. The two chalazal nuclei are unlike in size, the one near the center of the sac being slightly larger. The surrounding nucellar cells undergo disintegration, and their nuclei are freely liberated in the sac. Vacuoles are larger at the center of the sac, and cytoplasm thickest at the two ends. The nuclei apparently rest at this period.

When the sac reaches the octonucleate stage, it seems that the enlargement of the sac has gone far enough. All the chalazal cells show great depletion, almost to the micropylar end (fig. 11). This therefore makes the nuclei appear to be at the center of the sac. The micropylar group consists of three nuclei of the same size, one of which is the polar nucleus (*pn*). The larger one is the egg (*e*); the two similar ones are the synergids (*sy*). The chalazal group consists of



FIGS. 11, 12.—Fig. 11, octonucleate stage of embryo sac before final orientation of nuclei: *e*, egg; *sy*, synergids; *pn*, polar nuclei; *an*, antipodals; ×890. Fig. 12, fusion of polar nuclei; ×1060.

three congregated antipodals (*an*) and the elongated polar nucleus. It seems evident that the polar nucleus from the chalazal region is much larger than that from the micropylar region. The antipodals migrate to the chalazal pole, and before the fusion of the polar nuclei begin to disintegrate. The union of the two polar nuclei (fig. 12) is accomplished by the motility of the two nuclei approaching each other, and meeting and coalescing near the center of the embryo sac. The polar nucleus of the chalazal region apparently is at rest and the micropylar one appears more motile. This same condition occurs in *Luzula*, *Alisma*, *Carex*, *Triglochin*, *Orchis*, *Ornithogalum*, and *Nothiscordum* (**22**). Coalescence takes place before fertilization and before the pollen tube tip has reached the embryo sac.

At the final orientation of the component parts of the sac, it tapers at both ends and becomes more enlarged at the middle. This is not a general rule, however, as other shapes may also be round, depending on the amount of absorption and destruction of the nucellar tissues by the developing sac. Fig. 13 shows a mature embryo sac, at the chalazal end of which are the three antipodals, which are faintly recognizable. They are surrounded by thick protoplasm, and connection with the rest of the contents of the sac seems lost.

At the micropylar end is the egg apparatus, which is derived from the nuclei at the micropylar group. Prior to the migration of the polar nucleus, the egg is already differentiated from the two synergids in size (fig. 11). It becomes greatly vacuolated and enlarged, and is inserted somewhat lower down in the walls of the embryo sac.

A complete *Cocos* embryo sac is pictured in fig. 13. The antipodals (*an*) have gone into progressive degeneration. The endosperm nucleus (*en*) has assumed a central position, with a massive nucleolus, and with a spherical form. The egg apparatus, consisting of a very prominent egg (*e*) and two synergids (*sy*), has approached maturity. At this stage the synergids begin to show signs of degeneration.

In the development of the ovule and embryo sac of *Cocos nucifera* much time is involved The internal growth of the axis of the flower must have begun long before the inflorescence has emerged from the outer spathe. The ovules differentiate and attain their natural position when the inflorescence has escaped from the outer spathe and

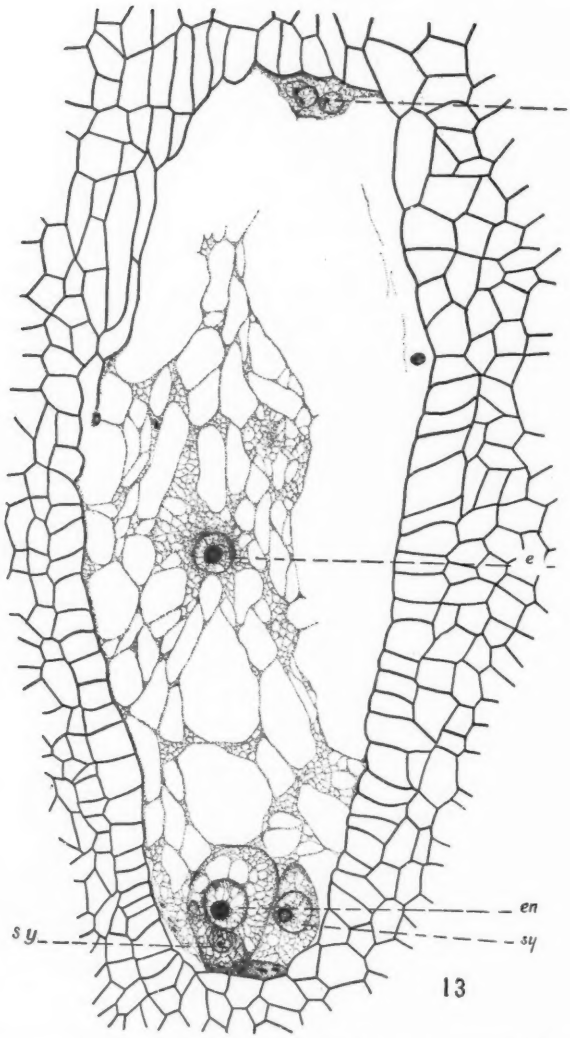


FIG. 13.—Mature embryo sac showing antipodals (*an*) at process of degeneration, endosperm nucleus (*en*) already formed, and synergids (*sy*) of egg apparatus at stage of degeneration; ×540.

made appearance from the axil of the clasping petiole. At this time the integuments are already formed.

Inflorescence	Megasporangium and Oogenesis
Inflorescence still inside of petiole, with outer spathe and inner spathe; 52 cm. long, and 15.3 cm. circumference*	Axil of the pistil already differentiated, bulging and initiation of ovules
Inflorescence out of outer spathe; circumference 14.3 cm.	Anatropous situation of ovules prominent
Inflorescence out of outer spathe; circumference 15.8 cm.	Outer and inner integuments formed
Inflorescence out of outer spathe; length 40 cm., circumference 18 cm.	Archesporial cell differentiated
	First division of megaspore mother cell
Inflorescence out of outer spathe; length 66.5 cm., circumference 27.2 cm.	Second division of megaspore mother cell
	Third division of megaspore mother cell
Just after opening of inflorescence	Fusion of polar nuclei and disintegration of antipodals
Emergence of stigmas (in receptive condition)	Disappearance of synergids and enlargement of egg and endosperm nucleus

* Length measured from base of lowest rachilla to tip of spathe; circumference based at largest portion of spadix.

Discussion

It has been the constant attempt of botanists to unravel, by a comparative study of the development of their gametophytes, that complicated fabric of phylogenetic relationships existing among plants. Unless a thorough study of nearly all the species known is carried out, no fair comparison can be made. It must be understood, however, that it is not within the scope of this investigation to offer any solution of this question.

The female flower arises as an emergence in the axil of the tertiary bract of the rachilla. At the axil of the tertiary bract and the floral cone, small papillate protrusions appear, which elongate, bend, and cover the juvenile flower. As soon as these scale leaves develop,

the three sepals appear simultaneously from the basal portion of the flower primordium, one overlapping the other at the apex. The petals, alternating with the sepals, next emerge simultaneously, first as rudimentary papillae, and soon differentiating like the sepals. The next to the last structure to emerge is the aril. The carpel walls are the last to develop.

The ovules may be considered cauline, as they arise from the central axis of the flower. In *Balanophora* and *Loranthus* (7) several writers found a similar situation, where a structure (or "mamelon") arises at the bottom of each sporangial chamber and grows until it completely fills it. *Rhopalocnemis phalloides* exhibits similar growth of the floral axis, especially before the appearance of the archesporium. The floral axis of *Cocos nucifera* enlarges, and toward each loculus is produced a papilla which serves as nucellus of the ovule. In other words, the nucellus of the nascent ovule is directed toward the receptacle. This case, where the usual development of the anatropous ovule is not followed, is an exception to the rule. The integuments are two, inner and outer.

Only one cell constitutes the archesporium, which according to our observation functions as a megaspore mother cell, and develops into the sac direct. According to RADERMACHER, *Nipa fruticans* also possesses an archesporium of one cell.

The cells of the archesporium, whether they be one or more, may by transverse division give rise to a primary parietal cell and a primary sporogenous cell. In *Cocos*, however, the archesporium, which is one-celled, never cuts any parietal cell. COULTER and CHAMBERLAIN (7) quote that *Avena fatua, Allium, Hemerocallis, Lilium, Erythronium, Tricyrtis, Sisyrinchium iridifolium, Gymnadenia conopsea, Orchis pallens*, and also *Commelina stricta* and *Iris stylosa* (10) do not develop any parietal cell. *Canna indica* (10) sometimes develops a parietal cell and sometimes does not.

The archesporial cell functions directly as the megaspore mother cell similar to *Lilium, Fritillaria, Funkia, Tulipa, Convallaria* (23), and *Erythronium* (19). Among the primitive aquatic plants, COULTER and CHAMBERLAIN give *Typha* and *Alisma* as exhibiting similar development of the megaspore mother cell. HALL (11) cites *Limnocharis* as possessing parallel development of the megaspore mother

cell. CALDWELL (3) reports that the mother cell does not divide in *Lemna*. Among the higher families *Narcissus* (10) and *Costus* (12) possess an undividing mother cell. *Nipa* (18) also shows an undividing megaspore mother cell, similar to that of *Cocos*.

BAUCH stated that a sign of degeneration of megaspores was found by him. Unfortunately the original article of BAUCH could not be obtained, so a fair comparison could not be made. However, judging from his statement[3] he seems to believe that the megaspore mother cell must have divided to form the two daughter megaspores, the chalazal becoming functional. This is contrary to what is reported in this paper. This discrepancy and divergence of interpretation is not uncommon; the case of *Richardia africana*, where MICHELL and GOW (16) seem not to agree as to the origin of its sac, is an example of differences of this kind. GOW found its origin to be a duplicate of *Cocos nucifera*, but MITCHELL found that four megaspores were produced. We base our conclusion on observations in the examination of hundreds of slides, and believe that the production of the megaspores or the tetrad in the normal development of the sac is entirely suppressed. Signs of disintegration of the megaspores were observed by BAUCH at the micropylar region of the sac. In many of our preparations we have found remains of nuclei from the nucellar cells undergoing absorption by the developing sac at the micropylar end (fig. 10). Two, three, or more nuclei may be crushed together and stain deeply so as to give an appearance of distintegration, or what BAUCH might have termed daughter megaspores experiencing disintegration or degeneration. These nuclei are plentiful, especially at the quadrinucleate stage of the sac.

The development of the megaspore mother cell into the embryo sac direct is not only found among the monocotyledons, but also in the dicotyledons. COOK (6) on *Rhytidophyllum*, CHAUVEAUD (5) on *Vincetoxicum*, YOUNG (24) on *Melilotus alba*, DASTUR (8) on *Hydnora africana*, and D'HUBERT (9) on *Opuntia* report cases of undividing mother cells. *Peperomia*, *Piper*, and *Heckeria*, as mentioned by JOHNSON (13, 14), also develop undividing mother cells.

The regular division from the megaspore mother cell (or 1-nucleate stage of the embryo sac) to the octonucleate sac, follows the usual

[3] Cited by RADERMACHER.

situation common in *Calopogon* (17), *Epipactis* (2), and in *Epidendrum variegatum*, *E. cochleatum*, *E. verrucosum*, *E. globosum*, *Coelogyne massangeana*, *Pogonia macrophylla* (20), and others.

The early degeneration of the antipodals, previous to the fusion of the polar nuclei, seems to indicate that they are ephemeral and do not persist long, as in *Nephrosperma* and *Vershaffeltia* (1). Typhaceae, Naiadaceae (*Potamogeton*), Alismaceae, Pontederiaceae, Liliaceae (except *Ornithogalum*), Scitamineae, and Orchidaceae (10) show ephemeral antipodals.

It is evident, as with *Eichornia* (21) and *Lilium* (7), that the fusion of the polar nuclei forms the endosperm nucleus.

Summary

1. The axis of the flower must have developed long before the emergence of the inflorescence from the outer spathe, and develops the ovules after it has escaped from the spathe. The development of the embryo sac continues and proceeds up to about the receptive stage of the stigma.

2. The ovules are cauline, arising from the central axis of the flower. The floral axis bulges out, and papillae which serve as the nucellus of the nascent ovules are pushed toward each loculus of the ovary. The inner and outer integuments develop in succession.

3. The archesporium is one-celled, which does not cut off any parietal cell, but functions directly as the megaspore mother cell, which develops the embryo sac.

4. The megaspore mother cell divides in the usual manner, and produces the octonucleate sac, hence upon maturity we have the egg, two synergids, two polar nuclei, and three antipodals.

5. The polar nuclei fuse just after the opening of the inflorescence and before the degeneration of the antipodals and synergids. The polar nuclei migrate toward the center of the sac, where they fuse.

6. The synergids begin to disappear just before the time when the ovary becomes receptive.

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REVEGETATION OF A DENUDED TROPICAL VALLEY

DUNCAN S. JOHNSON

(WITH FIVE FIGURES)

On November 8 and 9, 1909, the Blue Mountain region of Jamaica experienced an unprecedented rainfall of 27 inches, 18 inches in one 24-hour period at Cinchona. This caused disastrous floods, with great loss to the coffee plantations and to the vegetable gardens of the negro planters in the hills. Scores of acres of coffee fields were stripped to the bare rock, and even native forest was torn from the higher mountain sides, where the rainfall was probably heavier yet, and washed down the rivers to the sea, a mile below and a dozen or more miles away.

The valley of the Cascade River (fig. 1), which drains part of the southern slope of Mossman's Peak in the Blue Mountain Range, offers an excellent example of the havoc wrought by this flood. Six years and three years before the flood (1903 and 1906) the writer had crossed this valley near the 3000 ft. level, on the way from Cinchona to Blue Mountain Peak. It was then covered by a practically continuous forest, composed of many species of dicotyledonous trees with abundant shrubs and lianas. SHREVE (**4**) in a similar forest nearby noted, besides occasional species, 33 species of characteristic trees and shrubs, 12 lianas, and 34 ferns and herbaceous angiosperms.

In 1910 I again crossed this valley at the same level, and was startled to see how completely the flood had destroyed the forest seen there in 1903 and 1906, as well as the coffee fields and native forest higher up. Now, six months after the flood, the coffee trees were gone from many acres of the mountain side, the buildings of the Whitfield Hall coffee works had been crushed by a landslide from the hill above, and the débris from this and from landslides in other gullies was washed down to help bury parts of the valley floor below. A photograph made in 1926 showed nothing in sight at the works but one corner of the cement drying floor or "barbecue." All but this

small corner of the barbecue was covered by detritus from a cliff above, and now, after sixteen years, it is overgrown by cane and bushes and young trees that flourish in the seepage from a water conduit that formerly supplied the water wheel at the coffee works.

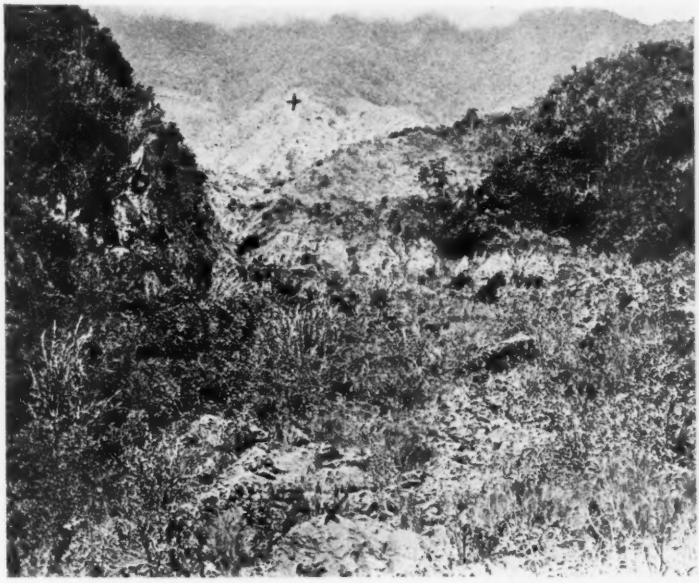

FIG. 1.—View looking up Cascade Valley over area studied, showing *Arundo*, *Baccharis*, *Myrica*, *Piper*, *Vernonia*, and *Rhytidophyllum* (at *X*) photographed June 1926, when clouds covered the large washout; cf. Johnson (2) fig. 2, noting in both the points here marked *o* and +.

The floor of the valley, 500 yards below the works, where I crossed it for the third time in 1910, was now a desert-like waste of bowlders and gravel for the whole 200 yards of its width (1). It was not merely the herbs and shrubs of the forest floor that were gone, but the large trees with their covering of epiphytes and lianas had disappeared completely. The only plants seen in this stony waste in 1910, across the whole width of the valley where our trail crossed it, were very scattered seedlings of the Papaveraceous shrub *Bocconia frutescens*, or celandine, and far fewer seedlings of half a dozen other

dicotyledons common on the surrounding hills. No lichens were seen, and no algae noticed save in the stream on the western side of the valley.

In July 1919 I again crossed the Cascade by the same trail, and was surprised to find how slowly the vegetation was recovering the waste area (**2**). Even then, nine and a half years after the flood, nine-tenths of the surface of the soil of this area was still bare rock and gravel. Relatively few of the many species growing abundantly on the surrounding hills had succeeded in becoming established in this rubble-like, well drained soil. A census of ferns and seed plants made at this time showed the presence in the formerly denuded area of seven ferns, of which *Gymnogramme tartarea* and *Pityrogramme calomelaena* were rather frequent, while *Trismeria trifoliata* was represented by dozens and *Pteris longifolia* by scores of plants. The other three ferns were rare. Many of these ferns were then so large (half a yard high or more) that it hardly seemed possible that they could have arisen from spore and prothallus in nine years. However, the absence of any sign of these ferns in 1910 and the fact that each clump of ferns seen in 1919 consisted of but one or two branches and leaf clusters, seemed to indicate that each fern plant had arisen where it stood from a prothallus. The sole monocotyledon seen, the cane *Arundo*, was confined to borders of the two branches of the stream, which join a little below the area. Of the twenty-one dicotyledons found, ten were Compositae, three were Asclepiadaceae, and two were Verbenaceae. More than half of them (14) were woody.

At that time *Vernonia permollis* was clearly the predominant plant of the area. Clumps ranging in size from seedlings up to plants 2 yards high were scattered throughout, but chiefly in definite although rather crooked rows along the minor gullies which drain the raised region between the main stream and a side branch entering from the east. After *Vernonia permollis*, *Bocconia frutescens* (then 2 or 3 yards high), *Solanum torvum*, and *Vernonia acuminata* (the two latter up to 2 yards high) were the most prominent plants scattered over the gravelly valley bottom.

The fifteen remaining dicotyledons, represented by from half a dozen to a dozen or two each, included species of *Piper*, *Pilea*, *Iresine*, *Begonia*, *Asclepias* (2 spp.), *Philibertella*, *Duranta*, *Verbena*, *Solanum*, *Maurandia*, *Ageratum* (2 spp.), *Mikania*, *Eupatorium*, *Bac-*

charis (a dozen or two plants), *Pluchea*, and *Bidens*. *Pilea* and *Bidens* were most numerous of all these.

Encrusting the surfaces of the pebbles and bowlders among which the dicotyledons grew was found the most abundant and constant species. This is the Chroococcaceous alga *Gloeocapsa magma*, which often forms velvety crusts half a foot square on the otherwise naked rocks that are of a rather bright maroon when moist but chocolate brown when dry. No lichens or mosses were noted in 1919.

In July 1926 I visited the Cascade Valley for the third time since the flood. The region along the trail is still sparsely covered with vegetation, perhaps a quarter to a third of the surface of the area being shaded by plants. Although the number of individual plants has not yet become sufficient to cover the ground, a number of new and interesting species have appeared.

Gloeocapsa still reddens large areas of pebble and bowlder surface across the whole width of the valley (fig. 2). Lichens are still so inconspicuous that Professor PLITT (in July 1926) at first thought them lacking. Further search revealed a very sparse lichen population, including altogether 18 species, most of them represented by only 5 or 10 specimens seen. On the rocks grew the crustose *Buellia* sp.? with the foliose *Leptogium* sp.?, *Parmelia perlata*, *P.* sp.?, *Anaptychia hypoleuca*, and *Coccocarpia pellita*. On the rocks also were found the fruticose *Stereocaulon cornutum*, *S. ramulosum*, and *Usnea hirta*. On the soil are *Cladonia pycnoclada* and *C.* sp.?. The bark of the shrubs bore *Haematomma puniceum*, *Lecanora subfusca*, *Parmelia perlata*, *Theloschistes flavicans*, *Usnea hirta*, and *U. rubigena*. Of all these only the *Buellia*, *Haematomma*, and *Lecanora* could be found in any quantity. *Usnea hirta*, although not numerous, is conspicuous because of its size. It is the sparseness rather than the presence of the lichens here that was most unexpected. But the persistence and even increase of *Gloeocapsa* on these hot dry rocks is very surprising, especially when we realize that it must often be exposed to a scorching tropical sun for many hours daily, and may be without rain for days or rarely for several weeks together. There is a copious dew in the valley each clear night, however, while on cloudy nights, as was often the case in 1926, the fog settled down to condense on the rocks and plants of its floor.

The total number of species of mosses, ferns, and seed plants observed in 1926 was forty-one. The rarity of mosses and the complete absence of liverworts from the new vegetation of this area is in striking contrast with their prominence as pioneers in burned-over tracts on the neighboring Blue Mountain Peak, a prominence they commonly have also in burned tracts in the temperate zones.

FIG. 2.—Group of fruiting plants of *Psilotum* growing between small bowlders; note young, simple shoot of this at left of knife; *Trismeria* at left and at extreme right *Gloeocapsa* on bowlders at right and below; (handle of pocket knife shown is 4 in. long); photographed June 1926.

Only one species of sterile moss was seen in 1926. Of pteridophytes, nine species are now established. Of these *Trismeria trifoliata* is most abundant (fig. 2). *Dryopteris oligophylla*, *Pteris longifolia*, and *Gymnogramme tartarea* are more moderately and about equally abundant. The pteridophyte I was most surprised to find last summer in this still desert-like habitat is *Psilotum nudum*, which had hitherto been seen but rarely in Jamaica and then always growing as an epiphyte. Here on the dry ridges and slopes of this gravel bed I found last summer over two dozen tufts of this *Psilotum*, growing sometimes in the scant shade of *Baccharis scoparius*, while else-

where, in the full sunlight, it grew out from between quite large bowlders (figs. 2, 3). How the rootless, humus-loving *Psilotum* can find adequate nutriment among these bowlders it is hard to guess. Its common occurrence here in this sort of substratum suggests at least something of the endurance of this archegoniate which has recently been regarded by KIDSTON and LANG as the most primitive of all living vascular plants.

Of the seven monocotyledons seen in the Cascade Valley last summer, the cane of the stream borders, *Arundo saccharoides*, is still by far the most abundant. Tufts of two smaller grasses, *Andropogon virginicus* and *A. gracilis*, are now scattered over the drier parts of the area, and two species of *Carex* accompany the grasses, although in smaller numbers. Quite unlooked for as an immigrant to the valley, at this stage of revegetation, was *Bletia verecunda*, which now grows freely, often two or three tall flower stalks together (2 or 3 feet tall), in the dry gravel and between the smaller bowlders. This orchid seemed to be flourishing in spite of the rapid drainage and the lack of humus; twenty plants were visible in one photograph. One vascular epiphyte *Tillandsia* (*setacea*?) was represented by two specimens seen, one on *Myrica*, the other on *Baccharis*. These two are the slender advance guard of this xerophytic epiphyte which will ultimately beset the trunks and branches of most of the woody plants of this area.

The dicotyledons are still, in spite of the recent invasion by the monocotyledons just mentioned, decidedly the dominant plants of this area, as they have been from the beginning. The two species of *Vernonia* and *Bocconia*, however, have now yielded the dominant place to two later comers, *Baccharis scoparia* and *Dodonaea angustifolia* Sw. (fig. 3). *Baccharis*, which was represented by but a few dozen small specimens in 1919, is now found in hundreds. These range in size from small seedlings to bushes 7 ft. high, with 2.5–3 inch trunks, and the fallen twigs of these plants are contributing as largely as any species to the scanty humus that is slowly accumulating between the pebbles. *Dodonaea* was rare and small in 1919, but it is now represented by dozens of plants, some few of them 8 ft. high with 1.5–2 inch trunks. These two shrubs now form the major part of the upper story of the vegetation. *Pilea microphylla* and *Micro-*

FIG. 3.—View of portion of area just below trail crossing, showing *Andropogon virginicus* (left below), *Baccharis* (left), *Pteris* (center above small card), *Dodonaea* (right between cards), and four colonies of *Psilotum* (each before a card) growing between pebbles strewn with fallen branchlets of *Baccharis* (card at left is 6.5×9.5 in.); photographed June 23, 1926.

meria viminea are present in scores, but are relatively inconspicuous because of their small size and their yellowish or reddish color. *Clusia havetioides*, common in forests at this level, as a *Ficus*-like epiphyte, has now populated the area with about 25 young specimens growing *on the soil*, often three or four in a group.

Perhaps the most striking woody dicotyledon is *Philibertella clausa*, an Asclepiadaceous vine with woody stems an inch in diameter and sometimes 100 ft. long, which sprawls in serpentine coils over many square yards of the warm gravel.

The remaining thirty-three dicotyledons are relatively scarce, and none of them is prominent except four or five plants of *Myrica microcarpa* just at the edge of the area and near the middle of the valley. These have now grown to trees with 4 or 5 inch trunks and crowns 10–12 ft. high but 15 ft. broad. Seen from the hillside above, their dark green foliage stands out against the prevailing gray green foliage and gray brown gravel.

At each visit to the Cascade Valley since the flood I have been surprised at the slowness with which the vegetation is recovering this virgin soil in a region where temperature, light, and rainfall are quite adequate for a rather dense forest. While it was assumed in 1910 that certain humus-inhabiting plants would be slow in settling on this new soil in the Cascade Valley, it was believed that a considerable number of the less exacting lichens, liverworts, mosses, ferns, and angiosperms from the neighboring hills would prove capable of settling there rather promptly.

There are then two important respects in which the course of repopulation of the valley floor has been surprising. The first of these is the slowness with which a complete covering of vegetation is developing. This is true in spite of the fact that 20 species of thallophytes and 41 species of cormophytes have, up to the present, established themselves on this area and are ready to cover it. Cursory observations were made in 1910 and 1926 of the revegetation of the floor of the Mabess Valley on the north side of the Blue Mountain Range, and at approximately the level of the Cascade area. These showed that here, with a similar average temperature, although a less varied one, with a greater rainfall and a higher humidity, the rocks along the stream that were bare in 1910 (just after the flood)

ing between pebbles strewn with fallen branchlets of *Baccharis* (card at left is 0.5×9.5 in.); photographed June 23, 1926.

TABLE I

PLANTS FOUND IN CASCADE VALLEY IN 1910, 1919, AND 1926

SPECIES	1910	1919	1926
ALGAE			
Gloeocapsa magma (Breb.) Kütz.		×	×
Nostoc sp.			×
LICHENS			
Anaptychia hypoleuca			×
Buellia sp.			×
Caloplaca sp.			×
Cladonia pycnoclada exalbercens			×
Cladonia sp.			×
Coccocarpa pellita			×
Haematomma puniceum			×
Lecanora subfusca			×
Leptogium sp.			×
Parmelia perlata			×
Parmelia sp.			×
Ramalina sp.			×
Stereocaulon cornutum			×
Stereocaulon ramulosum			×
Theloschistes flavicans			×
Usnea hirta			×
Usnea rubigena			×
ARCHEGONIATAE			
Moss (black, tufts sterile)			×
Adiantum tenerum Sw.			×
Aneimia adiantifolia (L.) Sw.		×	
Blechnum occidentale L.		×	×
Dryopteris oligophylla Maxon		×	×
Gymnogramme tartarea (Sw.) Desv.		×	×
Pityrogramme calomelaena (L.) Link		×	×
Pteris longifolia L.		×	×
Trismeria trifoliata (L.) Diels		×	×
Psilotum nudum (L.) Gris.			×
MONOCOTYLEDONEAE			
Andropogon gracilis Spr.			×
Andropogon virginicus L.			×
Arundo saccharoides Gris.	×	×	×
Bletia verecunda R. Br.			×
Cyperus sp. (foliaceous bracts)			×
Cyperus sp. (small, scattered tufts)			×
Tillandsia setacea Sw.			×

SPECIES	1910	1919	1926
DICOTYLEDONEAE			
Acacia ? (seedling)			×
Ageratum conyzoides L.		×	×
Ageratum houstonianum Mill.		×	
Asclepias curassavica L.		×	
Asclepias nivea L.		×	
Baccharis scoparia Sw.		×	×
Arenaria lanuginosa (Michx) Rohrb.			×
Begonia accuminata Dryand.		×	
Bidens incisa Ker.		×	
Bocconia frutescens L.	×	×	
Cecropia peltata L.			×
Clusia havetioides Planch. et Tr.			×
Crotalaria striata DC.			×
Daucus carota L.			×
Dodonaea angustifolia Sw.			×
Duranta plumieri Jacq.		×	
Eupatorium triste DC.		×	×
Gesneria exserta Sw.			×
Helosciadium leptophyllum DC.			×
Iresine celosoides L.		×	
Lantana odorata L.			×
Lantana stricta Sw.			×
Lisianthes longifolius L.			×
Maurandia scandens A. Gray		×	×
Metastelma sp. ?			×
Micromeria viminea (L.) Urban			×
Mikania scandens L. (Wild.)		×	?
Myrica microcarpa Benth.		×	×
Philibertella clausa (Jacq.) Vail		×	×
Pilea microphylla L. (Liebm.)		×	×
Piper sp.		×	×
Pluchea odorata L. (Cass.)		×	×
Rebulnium hypocarpium Endl.			×
Rhytidophyllum tomentosum (L.) Mart.			×
Senecio discolor (Sw.) DC		×	×
Silene ?			×
Solanum torvum Sw.		×	?
Verbena bonariense L.		×	?
Vernonia acuminata Less.		×	×
Vernonia permollis Gleason		×	×
Viburnum villosum Sw.			×

had by 1926 become completely covered by vegetation (figs. 4, 5). It seems clear that one chief preventative of the more rapid and complete reoccupation of the Cascade Valley by vegetation is the physi-

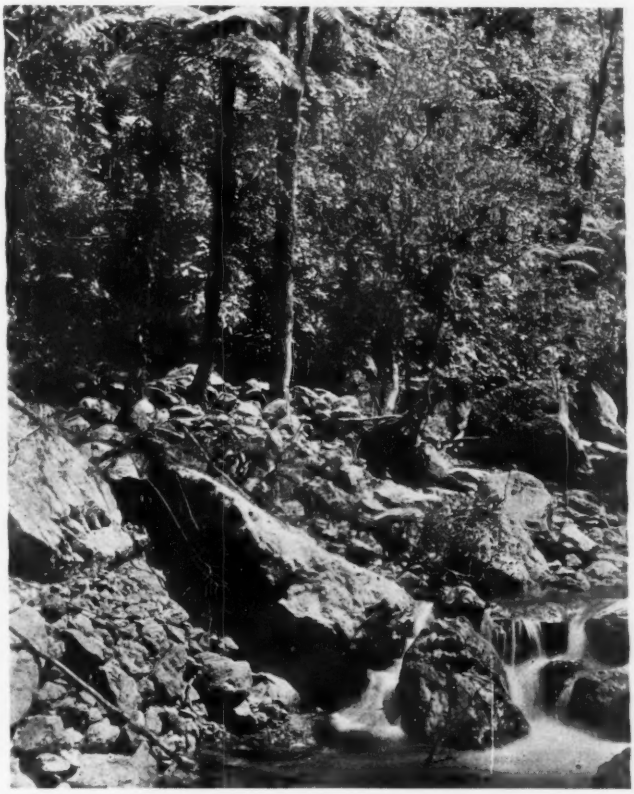

FIG. 4.—Banks of Mabess River (headwaters) taken June 1910, showing bare zone on each bank scoured clean by great flood of 1909; trunks of *Alsophila* with rosettes of *Caraguata* in background.

cal (rather than chemical) character of the shifting, well drained soil. On the other hand, it is evident that the considerably smaller and less evenly distributed rainfall, and the more constant sunshine of the Cascade Valley, as compared with the Mabess, has retarded the development of a complete covering of vegetation in the former.

The second surprising feature of the revegetation is the relative time of appearance of the several types of plant immigrants in this

FIG. 5 —Banks of portion of same stream, photographed July 1926, showing stream border recovered with vegetation down to normal high water level; in background are *Alsophila swarzii*, *Cyathea* sp.?, *Heliconia bihai* (L.) Sw., *Geonoma swarzii*, and *Lobelia* sp.?.

virgin soil. *Gloeocapsa magma* is the only thallophyte that appeared early (in this case on the rock surface). The lichens and mosses which WARMING (**6**) states are the first invaders of fresh soil, are only just now, after sixteen years, becoming at all evident in the area, when a considerable covering of as yet quite open communities of vascular plants has already become established. This is clearly true in spite of the fact that the Cascade Valley has a true forest climate, of which, as TANSLEY and CHIPP (**5**) state, "in a forest climate a new bare soil tends to be first occupied by the lower forms of plant life such as algae, lichens, and mosses." These usual pioneers, as they go on to state, are commonly followed in the order here named, by annual flowering plants, perennial herbs (including grasses), and these still later by shrubs and trees. In the Cascade area, on the contrary, the first plants evident were dicotyledonous shrubs and half-shrubs, for example, *Bocconia*, *Vernonia*, *Baccharis*, *Dodonaea*, *Philibertella*, *Solanum*, *Mikania*, *Eupatorium*, and seven others; while ferns and the herbaceous angiosperms were slow in appearing. Even now, after sixteen years, out of fifty-eight vascular plants established in this area nine are perennial ferns, seven are perennial monocotyledons; and of forty-two dicotyledons only five are annuals, while six are herbaceous perennials, and the remaining thirty-one are shrubs or trees. It will thus be seen that in this tropical valley the whole order of immigration and establishment described by WARMING and by TANSLEY and CHIPP has been almost completely reversed. Whether this inverted order of establishment is generally characteristic of tropical regions must be determined by further observation. It is certainly surprising that the lichens, which in general need plenty of light, should be so slow in settling on the fresh rock surfaces of this valley. The absence of xerophytic bryophytes is also very unexpected and as yet unexplained.

It is hoped that further data concerning the progress of the revegetation of this valley, including something of its seasonal aspects, can be gathered during the coming decade or two. The preceding account may serve as a picture of the vegetation already established there in 1926.

Acknowledgment is here made to Professor C. C. PLITT for information embodied in this note concerning the lichens of this area

and to Dr. N. L. BRITTON, Dr. A. S. HITCHCOCK, and W. R. MAXON for the identification of dicotyledons, grasses, and ferns respectively. M. S. CURTLER aided by collecting the vascular plants of the area studied.

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MEIOTIC IRREGULARITIES IN A GIGAS FORM OF POTENTILLA ANSERINA[1]

MURIEL V. ROSCOE

(WITH PLATE X AND TWO FIGURES)

Methods and material

The buds for this study were collected on warm days, cut with a sharp razor, placed in chromo-acetic (0.75 per cent) solution and pumped. Fixation was followed by thorough washing in water and bleaching in a 10 per cent solution of a concentrated solution of sodium chlorate in hydrofluoric acid. They were then imbedded in nitrocellulose, and 5 and 10 μ sections cut. These were stained with Haidenhain's haematoxylin, and studied with a 1.5 mm. Zeiss objective and no. 12 ocular.

A "*grandis*" form of *P. anserina* L.[2] collected in Cape Breton, Nova Scotia, was featured, in addition to its *gigas* development, by pollen sterility and lack of fruit formation. Fig. 1 is a photograph of the aberrant and the normal forms, and shows clearly the vegetative luxuriance of the former. In contrast to the normal *P. anserina*, the "*grandis*" form is not found in the regular salt marsh, but at beach heads, where it gets the wash of the salt water but rarely.

Cytological observations

Late prophases or diakinesis stages show variable numbers of chromatin units. The variation in these numbers is probably due to a loose union of the paired or bivalent chromosomes. LONGLEY (18) found in some specimens of *Tripsacum* both univalent and bivalent chromosomes, which "makes the assigning of a definite haploid chromosome number difficult." Similar difficulty has been experienced in this form of *Potentilla anserina*.

[1] Contribution from the Laboratories of Plant Morphology, Harvard University.

[2] According to FERNALD'S revision of the representatives of *Potentilla anserina* in Eastern America (7), the variety *grandis* T. & G. is included in *P. pacifica* Howell. The form under discussion, on account of its pubescence, is considered a "*grandis*" form of *P. anserina* L.

The plate shows division figures for this form. Metaphases are rarely regular, and figs. 3 and 4 are representative of the differences in chromosome number and degree of pairing. True metaphase plates are never formed. The chromosomes are distributed to the poles irregularly, and the process is featured by a number of laggards, some of which become left outside at interkinesis. The latter are univalents, and a portion are always resolved into micronuclei (fig. 5).

FIG. 1.—*P. anserina*, photograph of the *gigas* and normal forms

The unequal distribution is a cause for further abnormalities in the homotypic division. Fig. 6 shows an extremely irregular metaphase. The spindle on the left has received 22 chromosomes, which are very diverse as to size and arrangement. The spindle on the right contains a much smaller number, whose arrangement is indicative of abnormality.

Homotypic anaphases are abnormal (fig. 7), and in the majority of cases lead to a condition of polycary. An abnormality with three large nuclei of uncertain origin (fig. 8) is frequently seen, and undoubtedly is attributable to the hybrid constitution of the parent.

A drawing of a group of cells showing the end product of the second division is shown in fig. 2, and serves as a forceful illustration of polycary as a resultant of irregular chromosome distribution. The

cytoplasm of all the pollen mother cells during division is much vacuolated, and its appearance suggests degeneracy. The reduction division of this *gigas* form of *Potentilla anserina* is thus featured by abnormalities of various sorts, and it is not surprising that high degrees of pollen sterility result. In a majority of the mature loculi there is complete absence of cytoplasmic grains, a condition not found in the normal species, where well formed pollen is the rule.

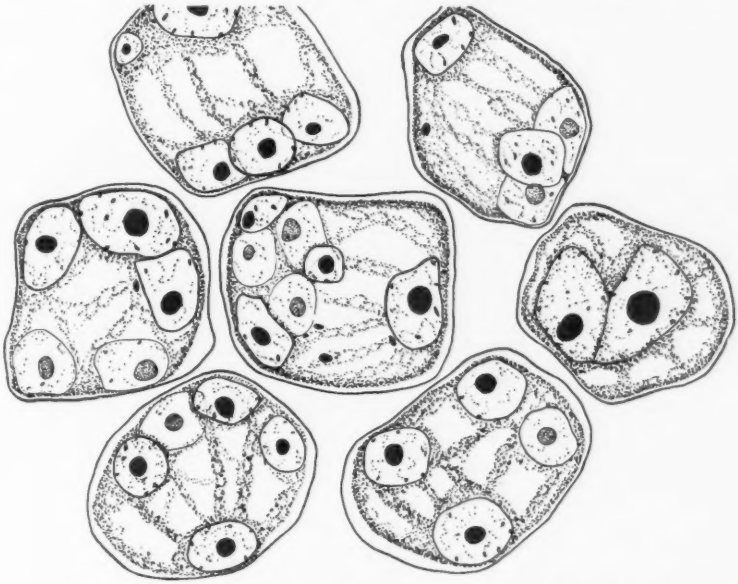

FIG. 2.—*P. anserina*, *gigas* form: polycary resulting from irregular chromosome distribution during meiosis; ×approximately 1200.

Discussion

WULFF (25) made an examination of the pollen of various species of *Potentilla* and found far reaching sterility. After considering the causes of sterility in other cases, namely hybridity, mutation, and environmental factors, he was unable to determine which of these operated to produce *Potentilla* sterility. He believed, inasmuch as percentages varied with geographic location, that sterility was somewhat due to the influence of the outer environment. At the same

time he did not exclude other causal factors, and suggested that hybridity probably occurred in some species; and further, "diese Pollensterilität ist derjenigen bei den der *Potentilla* verwandten Gattungen *Rubus*, *Rosa* und *Alchimilla* analog." Since the time of this allusion, the cytological investigations of LONGLEY (**17**) on *Rubus*, and of TÄCKHOLM (**20**) and BLACKBURN and HARRISON (**2**) on *Rosa*, have shown the connection between divisions and sterility for the first two genera. WULFF found the pollen sterility of *P. anserina* var. *vulgaris* Hayne to range as high as 34.13 per cent. In the *gigas P. anserina* there is a still greater amount, and the percentage is often as high as 100.

ROSENBERG'S treatment of *Drosera obovata*, *D. longifolia*×*rotundifolia* (**19**), is a clear-cut case where the irregularities of division are caused by univalent or unpaired chromosomes. Those left outside the daughter nuclei form micronuclei, and in the second division usually develop small spindles. Disorganization appears clearly a little later, when the pollen grains have separated. The protoplasm of the pollen mother cells of this hybrid is "in weniger reichlicher Menge."

As early as 1900, GUYER (**10**) found that some pigeon crosses were fertile, some crosses non-fertile, and he summed up the features of hybridity as: "(1) abnormalities in meiosis; (2) abnormalities in the structure of the spermatozoa; (3) degeneration of the germinal cells." GUYER believed the conflicting tendencies of parent plasms frequently render the formation of bivalents impossible, and suggested that both cytoplasm and chromatin were involved in the physical basis of heredity.

FEDERLEY (**6**) studied *Pygaera* species and hybrids, and showed that normal reduction occurs in pure species; in the primary hybrids, on the contrary, there is no conjugation of the "artfremden" chromosomes, and the diploid number is the sum of the haploid numbers of the parents. Abnormalities occur in both divisions but more especially in the second, and, as a result, spermatids with double nuclei often occur. These *Pygaera* crosses are rarely fertile, and the sterility is explained on cytological grounds.

WODSEDALEK'S research (**24**) concerning division and resultant sterility in the mule provides an emphatic case where complete sterility results from the union of gametes, whose chromatin proved

both quantitatively and qualitatively dissimilar. The more recent discoveries of JEFFREY and HICKS (**13, 14**) disclose meiotic anomalies for *Drosophila melanogaster* quite akin to those described and figured by WODSEDALEK. The elimination of chromatin and the abnormal method of meiosis are considered in this case indicative of heterozygous constitution.

Still more numerous cases of hybridity, both naturally and artificially produced, have been investigated in plants. TISCHLER in 1908 (**21**) described the cytology of *Potentilla tabernaemontani*×*P. rubens*, as well as that of the parents involved. In the hybrid, the nuclear figures in the dividing pollen mother cells, despite the presence of 16 definite pairs of chromosomes at diakinesis, show that the daughter nuclei receive unlike masses of chromatin, and as many as 20 units have been noted in one nucleus, along with a correspondingly smaller number in the other nucleus. This feature of division, coupled with the deficient amount of cytoplasm, will be recognized to be much like the condition in the sterile *P. anserina*. TISCHLER notes also that frequently in the homotypic only one dyad divides and the other remains undivided. Further irregularities very similar to those in the hybrid are found in one of the parents, for *P. tabernaemontani* shows often an "überzähliger Nucleus" and "versprengte Chromosomen." These are followed in the parent as well as in the hybrid by the production of sterile pollen. Thus there is little difference noted between the parent and the hybrid: "damit dürfte beweisen sein, dass irgend ein prinzipieller Unterschied sich zwischen der Taubheit das Hybriden und der von *P. tabernaemontani* nicht vorfindet."

FARMER and DIGBY (**5**) found in *Polypodium schneideri* (=*P. vulgare* var. *elegantissimum*×*P. aureum*) that few spore mother cells pass through meiosis, and those that do are abnormal, have small amounts of cytoplasm, and show chromosome lagging. The form is of hybrid origin and the cytology confirms it. However, one of the parents also showed irregular phenomena, and these investigators therefore felt that irregularities do not necessarily connote hybridism, the conclusion earlier reached by TISCHLER.

Miss LJUNGDAHL has recently published accounts of her studies on spontaneous and artificial hybrids of *Papaver* (**15, 16**), and has shown varying amounts of union between the homologous chromo-

somes; it was observed that union may at times fail completely. Conclusions regarding *Papaver somniferum*×*P. orientale*, very similar to those of Miss LJUNGDAHL, were made earlier by Miss YASUI (**26**). She noted that F_1 plants were more vigorous than their parents, and states:

> The irregular behavior of chromosomes in the meiotic division, the union of two nuclei, and dropping of certain chromosomes cause the abnormalities of pollen grains, not only in shape and size, but also in the combinations of the heredity substances. This may contribute to the origin of the variation or new forms in the offspring on the one hand, while this may affect the viability of the male gametes and cause the sterility on the other hand.

Thus for *Papaver* crosses, both Miss YASUI and Miss LJUNGDAHL showed: (1) that there is a greater or lesser amount of pairing; and (2) that the lagging of univalent chromosomes on the spindle gives various results.

With the disclosures of the last twenty years showing that abnormal divisions so frequently accompany the reduction division of hybrid plants and animals, these phenomena have come to be regarded as criteria of pure as contrasted with hybrid-originating species. Many "species" have been shown to possess such characteristics as are associated with hybrids.

EKSTRAND'S brief paper on *Plantago major* (**4**) gives cytological figures which showed irregularities from diakinesis onward, where the chromosomes became shared unequally, and often one or more chromosomes were left outside and formed dwarf nuclei. Such species as *P. psyllium* and *P. depressa* were regular.

HOLMGREN (**12**) gives figures furnished by the peripheral anthers of *Eupatorium glandulosum*, showing much the same sort of loitering at heterotypic telophase as was viewed in the aberrant *P. anserina;* also regular tetrads never occurred in the species. He considered the constitution of *E. glandulosum* very like that of *Polypodium aureum* × *P. vulgare* var. *elegantissimum*, and of FEDERLEY'S *Pygaera* hybrids. For similar reasons he decided that *Erigeron annuus*, as well as *Eupatorium glandulosum*, arose through hybridization.

GOODSPEED (**8**) found F_1 hybrids of *Nicotiana sylvestris*×*N. tabacum* var. "*mirdato*" to have uniformly defective pollen. Abnormalities in homotypic division were abundant, and occasionally giant

spindles like those in Miss LJUNGDAHL's *Papaver* hybrids could be seen. Usually, however, no conspicuous number of chromosomes were left outside.

Miss CAMPIN (**3**) described irregular methods of pollen formation in *Solandra grandiflora*, and says, "during the reduction division, however, and more particularly during the anaphase of the heterotypic division, there are striking deviations from normal behavior." In this species the chromosomes are extruded to the periphery of the cytoplasm, where they either perish or form accessory nuclei; in most cases they arrive at the poles, but counts of the two nuclei may differ widely: "sometimes 11, 12 or even a higher number of chromosomes will arrive at one pole, while the other has a smaller number, 5, 6 or less." Like the *P. anserina* under consideration, there is a quantitative difference in the chromosomes at the end of the first division.

TISCHLER in 1925 (**22**), after reviewing the more recent investigations, states:

> Seltsam ist es, dass die Abnormitäten, die durch GREGORY (1905) für *Lathyrus odoratus*, durch WHITE (1913) für *Nicotiana* . . . . durch EKSTRAND (1918) für *Plantago major*, durch BEER (1921) für *Geranium ibericum*, etc., beschrieben sind, ganz denen gleichen, die wir bei Bastardiserung kennen lernten.

We may add to this the case of the sterile *P. anserina*, which possesses abnormalities comparable with those reviewed, and which we have come to expect in experimentally produced hybrids.

Conclusions

The irregularities of reduction in the sterile *P. anserina* are probably due to dissimilarity of the parental chromosomes. TISCHLER (**21**) suggested that qualitative agreement of these chromosomes is necessary for subsequent regular chromosome action. As shown by ROSENBERG (**19**), however, lack of quantitative agreement is also responsible for abnormalities. It is suggested that for this *Potentilla* the presence of univalents in addition to bivalents is due to chromosome dissimilarity, either qualitative or quantitative. It is believed that a loose union of the bivalents exists in diakinesis, which allows varying numbers of univalents to appear in metaphases of different cells, and these univalents are responsible for much of the irregu-

larity on the spindle. The abnormalities of division cause the production of various numbers of nuclei at the close of the homotypic. Most of the microspores disintegrate and are factors in the formation of large amounts of sterile pollen.

Notable features are the vegetative luxuriance of the plants, the cytoplasmic poverty of the pollen mother cells, and the appearance of abnormalities of reduction featured by irregular chromosome distribution, which lead to a condition of polycary and eventually of pollen sterility. Finally, this form is usually wholly unable to form fruits.

From a comparison of these with the results of other investigators on plants with known hybrid origin, and on others with suspected heterozygous constitution, one is led to suggest that this infertile *P. anserina* is a product of hybridity.

Summary

1. An aberrant form of *Potentilla anserina* was characterized by gigantism, sterile pollen, and lack of fruit formation.

2. Dividing pollen mother cells of this form reveal irregularities of various sorts.

3. The heterotypic division shows bivalents and univalents, chromosome lagging, irregular chromosome distribution, and the formation of micronuclei.

4. The homotypic division discloses further abnormalities in chromosome distribution, which frequently lead to the development of a condition of polycary.

5. Meiotic irregularities are due to the dissimilarity, either qualitative or quantitative, of the parental chromosomes.

6. Sterile pollen results from the irregular meiosis.

7. This form of *P. anserina* is considered, on the basis of such features, to be a hybrid.

This investigation has been carried on under the supervision of Professor E. C. JEFFREY, and I wish here to express my sincere appreciation of his interest and assistance.

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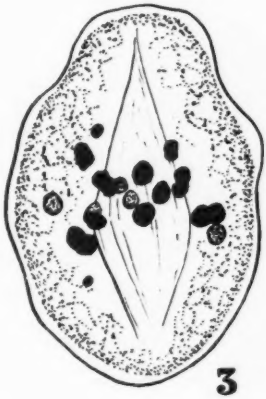
EXPLANATION OF PLATE X

P. anserina L., *gigas* form; pollen mother cells during meiosis; ×approximately 2000.

FIG. 3.—Metaphase, heterotypic.
FIG. 4.—Metaphase, heterotypic.
FIG. 5.—Interkinesis.
FIG. 6.—Metaphase, homotypic.
FIG. 7.—Anaphase, homotypic.
FIG. 8.—Abnormal cell showing three large nuclei formed during meiosis.



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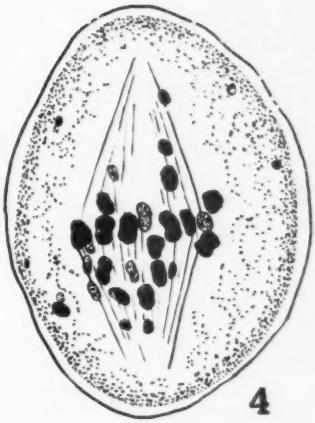

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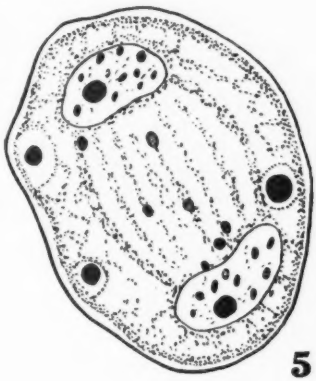

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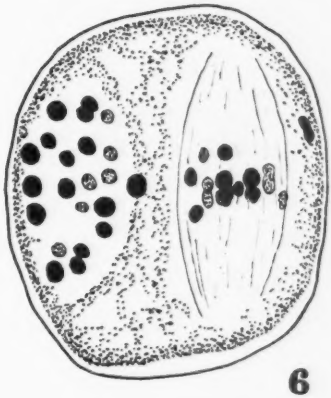

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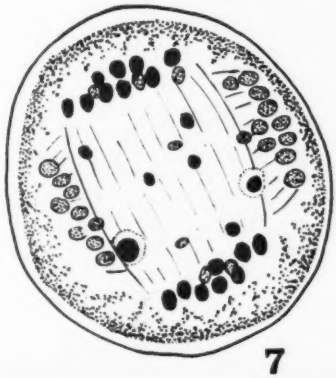

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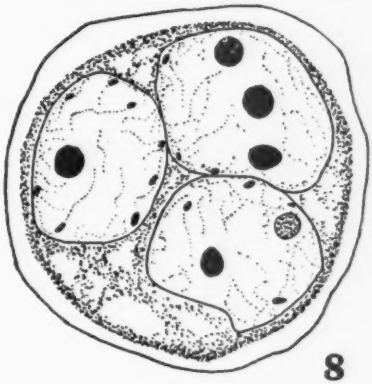

8

ROSCOE on POTENTILLA

CONSTANT RATES OF CONTINUOUS SOLUTION RENEWAL FOR PLANTS IN WATER CULTURES[1]

J. W. SHIVE AND A. L. STAHL

(WITH ONE FIGURE)

In studying the nutrition of plants experimentally, it is very desirable that the initial salt proportions of the culture medium should remain fairly constant during contact with the plant roots. The initial composition of a mixed salt solution used for water cultures may be known accurately, but when the quantity is limited, as it necessarily is in experimental studies of this type, the salt and ionic proportions of the solution begin gradual alteration immediately after introducing into it the roots of vigorously growing plants. Ions move from the solution into the roots as well as in the opposite direction, different ions being absorbed and excreted at different rates, causing the solution to become significantly altered from its original composition where limited quantities are employed. In order that the unknown alterations may be regarded as negligible with respect to their influence upon the growth of the plant, and that growth may be correlated with the chemical conditions surrounding the roots, it is obviously necessary not only that a relatively large quantity of the solution be employed for each culture, but also that this quantity be renewed frequently. The ideal method, of course, is continuous renewal of the culture solution at a constant rate for each culture in the experimental series by some method of "drip and drain." If the rate of flow is rapid enough, the composition of the solution will not be altered significantly by contact with the roots of growing plants, and the roots may then be considered as having been grown under a set of known chemical conditions throughout the period of growth of the plant.

The need of continuous solution renewal in experimental studies with water cultures has long been emphasized, and many investi-

[1] Paper no. 351 of the Journal Series, New Jersey Agricultural Experiment Station, Department of Plant Physiology.

gators have employed methods by which this was accomplished, without particular consideration, however, of the rates of renewal. As long ago as 1865, NOBBE (4) flowed solution into a vessel containing the roots of growing plants, but he made no attempt to control the rate of flow. In recent years the need of continuous renewal of culture solutions has been emphasized by STILES (6), who urges that the chemical conditions surrounding the roots of experimental plants should be known and as constant and invariable as they can be made. CONNER and SEARS (2) have expressed the same desire for continuous renewal of culture solutions. DUGGAR (3), also emphasizing this need, makes the not too optimistic suggestion that the operation of a system by which this desirable condition might be realized would be impracticable in most experimental work.

TRELEASE and FREE (8) have shown that in solution cultures plants improve in vigor and growth rates as the time interval between solution renewals decreases, but they obtained better results with continuous flow of solution than they did with intermittent daily solution renewal. TRELEASE and LIVINGSTON (9) strongly emphasize the need of flowing solutions in experimental work with water cultures, as do also ALLISON and SHIVE (1), who have shown that solution or sand cultures with continuous solution renewal by which one liter of new solution per culture was supplied during each 24-hour interval throughout the growth period, always produced plants which were superior in every respect to those grown in corresponding cultures with intermittent solution renewal.

It is not particularly difficult to devise a simple means of continuously flowing a solution through a culture vessel containing growing plants when the question of a constant rate of flow is not an important one. But when constant rates of flow must be maintained over a considerable period of time, difficulties immediately present themselves. Some of these have been overcome, in a measure, by a method described by TRELEASE and LIVINGSTON (9). This method is very useful when only one solution is employed for a large number of plants, or when the same solution will suffice for each culture of an experimental series. Because, however, of the labor and expense involved in preparing the apparatus, which is

somewhat complicated, the method becomes almost impracticable when solutions differing in composition must be employed for each culture of a large experimental series. For the continuous renewal of solutions with such a series of cultures, by means of which a constant flow through the culture vessels is maintained, a complete system for this purpose must be provided for each individual culture of the series. This system, to be useful and effective, should be inexpensive, simple in construction, easy to operate, and must provide a continuous flow at an approximately constant rate over an extended period of time. The method here described fulfills these requirements. It has been in use in this laboratory for some time, and in all cases has given entire satisfaction.

Fig. 1 shows the main features of the necessary apparatus, which consists essentially of three parts: the constant level reservoir *A*, the capillary conducting siphon *D*, and the culture jar *B*, with the necessary inlet and outlet tubes *E* and *F*. The reservoir consists of an ordinary one or two-quart fruit jar of colorless glass, which in operation is inverted into a low, flat, glass dish (*C*) of appropriate size. A small dessert dish of colorless glass about 10 cm. in diameter and 3 cm. deep, such as was here used, serves very well. The reservoir is filled with the culture solution, and while still in the upright position, the glass dish is inverted over the opening of the jar and firmly held in position while the jar is being inverted.

The siphon *D* consists of a capillary glass tube about 28 cm. long with 0.5 mm. bore. The tube is bent, as indicated in the diagram, to fit over the edge of the glass dish with the short arm of the siphon long enough to extend several centimeters under the opening of the reservoir jar *A*, and resting on the bottom of the dish. To place the siphon in position, the jar is tilted to one side until the edge of the jar is raised just enough to admit the end of the tube, the rim of the jar then resting on the tube. As the jar is tilted air is admitted, and the solution will flow into the dish until the opening into the jar is sealed. When the siphon is in operation, the solution level in the dish gradually falls until the seal is broken and air is again admitted into the reservoir, when the solution will flow into the dish again to seal the opening. The fluctuation of the solution level in the dish never exceeds 1 cm., however, which is not sufficient to cause any

appreciable change in the rate of flow through the siphon, so that it may be considered as operating from a constant level reservoir. The

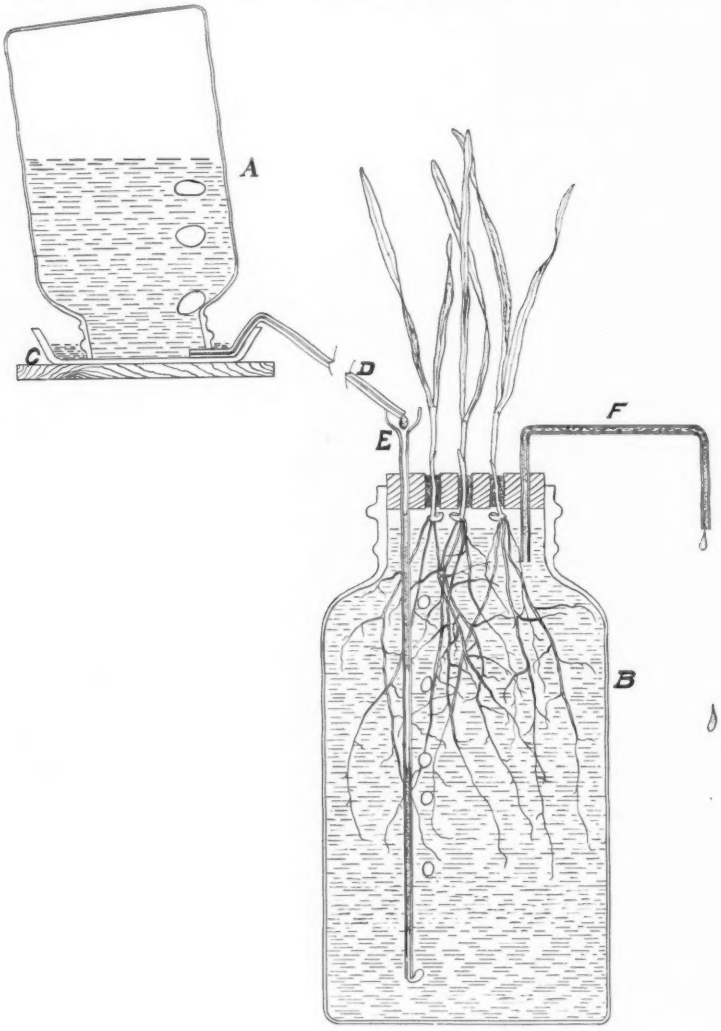

FIG. 1

rate of flow through the siphon is determined, in part, by the length of the capillary resistance, but may be regulated to any rate desired by adjusting the outlet of the tube to the proper distance below the solution level in the dish. By a few trial adjustments, carefully timing the delivery from the tube of several cubic centimeters of solution, the desired rate of flow may readily be obtained. The rate of flow through the capillary tubes is quite uniform when operating from a constant level reservoir. The tubes do not readily clog, as do rubber ones upon which metal clamps are set, and only an occasional cleaning is necessary.

The culture vessel consists of a two-quart fruit jar of colorless glass fitted with a paraffined cork stopper in which the plants are mounted as described by TOTTINGHAM (7). The stopper serves also as a support for the inlet and outlet tubes. The inlet tube *E*, having a bore of about 1.5–2 mm., and with a small funnel at the top, extends almost to the bottom of the culture jar. The funnel on the inlet tube may be prepared by blowing a small bulb about 2 cm. in diameter on one end of the tube. The upper portion of the bulb may then be heated and blown out until exploded, after which the edges may be melted down in a small blast or Bunsen flame to form a rounded funnel. The outlet tube *F*, about 18 cm. long, having a bore of about 2–3 mm., is bent into the form of a siphon, as indicated in the diagram. The arm of the siphon extending through the cork stopper is about 1.5 cm. longer than the other arm. When the culture jar is filled to the proper height, this arm of the siphon extends just below the surface of the solution, which lies in a horizontal plane passing through the other arm just above the outlet. When the system is in operation, the solution surface in the culture jar may be maintained automatically at any level desired by raising or lowering the siphon.

To install the apparatus, a suitable support must be provided to hold the solution reservoir and the glass dish 5–10 cm. above the culture jar, the exact height to be determined by the rate of flow desired. The culture jar, filled with the proper solution and with the plants and tubes supported as indicated in the diagram, is then placed in position so that the end of the siphon will rest on the edge of the funnel at *E*. If the tube is adjusted so that the drip from the

capillary will fall directly into the opening, air will be entrained by the solution and carried to the bottom of the culture jar, thus setting up an aerating system. This desirable feature, however, will not operate if the internal diameter of the tube is too large. A tube with a bore of 1.5–2 mm. is quite satisfactory. The siphon *F* is now started by applying suction, after which it will automatically take care of itself. It is important, however, that the bore of this siphon is not greater than about 3 mm., otherwise the surface tension may not hold the solution in the tube and prevent it from flowing back into the culture jar, if, for any reason, the flow through the capillary *D* should cease. A waste jar will catch the discard solution from the siphon.

To exclude light from the roots of the plants, the culture jar is covered with a cardboard shell in the manner described by SHIVE (**5**). To prevent undue exposure of the solution surface in the dish, and also to exclude light from the culture solution in the reservoir jar, these parts are also covered when the system is in operation. Waxed paper cans of the proper size, such as are used for ice cream containers, are ideal for this purpose. These cans, with a small rectangular slit cut in the top of each to fit over the siphon tube when the can is inverted over the reservoir jar and dish, afford all the protection that is necessary.

After being installed, the system is self-operating and requires only that the reservoir jar be refilled at the proper intervals and the siphons started after each refilling. The use of this system obviates the necessity of frequently removing the roots of the plants from the culture jar during the experimental period, which in the practice of intermittent solution renewal always subjects the roots to the danger of mechanical injury and infection.

The apparatus is simple in construction, compact, easy of operation, quite inexpensive, and when once installed, a series of cultures each operated under this system requires no more attention and involves no more labor than does a series comprising an equal number of cultures in the practice of intermittent solution renewal. A complete series of 36 cultures, each with its system of continuous solution renewal as here described, has been conducted on a rotating table (**5**) 5 feet in diameter.

With slight modification, the constant drip apparatus may be used with sand cultures where the solution is permitted to fall upon the surface of the sand in percolators such as were employed by ALLISON and SHIVE (1). As thus far used, the delivery tubes have been calibrated to supply each culture, comprising three plants, with 1 liter of new solution during each 24-hour interval throughout the experimental period.

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CHLORIDE AND SULPHATE ABSORPTION FROM CULTURE SOLUTIONS BY EGYPTIAN AND UPLAND COTTON SEEDLINGS[1]

A. R. C. HAAS

The physico-chemical properties of the leaf tissue fluids have been found to differentiate the Egyptian and Upland types of cotton, in addition to the external botanical characters. An extended series of determinations by HARRIS and his associates (**1–5**), upon the tissue fluids of the two types of cotton, have yielded the most interesting conclusion that they are differentiated with respect to the osmotic concentration, specific electrical conductivity, hydrogen-ion concentration, chloride and sulphate content. The tissue fluids of the Egyptian types had a higher osmotic concentration, specific electrical conductivity, and chloride content, but a lower sulphate content than those of the Upland types. The hydrogen-ion concentration of F_1 hybrids was intermediate between those of the two parental forms, being higher than that of the Egyptian but lower than that of the Upland parent. The plants were grown under irrigation, and recognition was made of the influence of substratum heterogeneity, which is a universal characteristic of experimental fields (**6**).

It seemed of interest to study the absorption of chloride and sulphate from culture solutions by Egyptian and Upland types of cotton seedlings, in order to ascertain whether or not the Egyptian type absorbs larger quantities of chloride and the Upland types larger quantities of sulphate. In culture solutions it was possible to maintain a given concentration of the chloride or sulphate ion in the nutrient medium, quite in contrast with the known fluctuations throughout a given soil mass under irrigation (**7**).

The cultures consisted of one-liter Pyrex beakers with heavily tinned, perforated lids to support the seedlings. The seeds employed were secured from W. B. CAMP, Agronomist in charge of the United States Cotton Field Station at Shafter, California, and from the Uni-

[1] Paper no. 162, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

versity of Arizona at Tucson. Seeds were germinated in pure silica sand, and the seedlings were transferred to the cultures after being carefully washed with distilled water.

Each culture contained a liter of solution. Sodium chloride of a given concentration was added to unmodified Hoagland's solution (10), but when sodium sulphate was the added salt a modified Hoagland's solution containing nitrate instead of the usual sulphate was employed. No sodium sulphate was added to one series of cultures in which the unmodified solution contained 0.3017 gm. sulphate per liter. Twelve seedlings were inserted through the perforations of each lid, the first leaves resting somewhat on the lid and acting as a support. The roots were protected from light by heavy paper wrappers, and the cultures were grown in the glasshouse under controlled conditions. From time to time distilled water containing iron tartrate was added to each culture. Series of cultures were grown at different times of the year.

After making considerable growth, the seedlings were washed with distilled water and the solutions made up to volume. The absorption of chloride or sulphate was indicated by the difference in the weights of chloride or sulphate as determined by the gravimetric method.

Table I gives the percentage of the original concentration of chloride or sulphate absorbed, together with data regarding the growth obtained in several of the cultures. The chloride cultures of May 19, 1926, showed greatest absorption by the Pima or Egyptian type, with a falling off in the absorption at the higher concentration.

In the June chloride cultures the Pima seedlings absorbed the most chloride from the more concentrated solution, but their absorption from the weaker solution was less than that of Acala or Lone Star seedlings. The November chloride cultures showed slightly less absorption by the Pima cultures than by the Mebane or Acala cultures. At the highest concentration of chloride used, the Egyptian type of seedlings showed a greater growth and absorption than the Upland type. At the lower concentrations the Egyptian type did not consistently absorb larger amounts than the Upland type. A larger absorption may result from greater growth of the seedlings, but absorption, growth, and transpiration may not necessarily be

TABLE I

ABSORPTION AND GROWTH OF COTTON SEEDLINGS FROM SOLUTIONS CONTAINING CHLORIDES OR SULPHATES

GROWTH PERIOD	ORIGINAL CONCENTRATION	PERCENTAGE ABSORBED				PLANT GROWTH							
						Pima		Mebane		Acala		Lone Star	
	Gm. per liter	Pima	Mebane	Acala	Lone Star	Fresh wt. of 12 plants (gm.)	Total length average plant (cm.)	Fresh wt. of 12 plants (gm.)	Total length average plant (cm.)	Fresh wt. of 12 plants (gm.)	Total length average plant (cm.)	Fresh wt. of 12 plants (gm.)	Total length average plant (cm.)
						Chloride							
May 19 to June 9, 1926	0.2610	34.1	19.9	21.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
May 19 to June 9, 1926	0.5940	17.5	{11.3 / 12.5}	12.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
June 9 to July 16, 1926	0.2855	39.4	33.2	41.3	43.3	48.5	45.0	54.8	37.5	57.5	40.0	52.0	37.5
June 9 to July 16, 1926	0.5879	43.5	17.6	28.1	15.9	68.5	52.5	36.0	32.5	45.0	31.3	29.5	27.5
November 22, 1926, to January 18, 1927	0.3080	48.0	53.3	55.4	39.8	58.0	45.0	70.0	30.0	70.0	32.5	49.0	27.5
November 23, 1926, to January 18, 1927	0.3080	40.3	44.8	43.1	36.5	52.0	40.0	53.0	28.8	54.0	27.5	49.0	27.5
						Sulphate							
May 19 to June 9, 1926	0.4960	22.2	15.5	13.7	10.7	.....	.....	.....	.....	.....	.....	.....	.....
May 19 to June 9, 1926	0.9620	16.0	11.2	11.7	7.8	.....	.....	.....	.....	.....	.....	.....	.....
June 9 to July 16, 1926	0.3017	71.3	41.9	66.7	50.9	60.0	55.0	53.0	43.8	58.0	42.5	.....	.....
June 9 to July 16, 1926	0.4972	.....	31.5	32.6	24.0	.....	.....	43.0	37.5	52.0	37.5	29.0	33.8
June 9 to July 16, 1926	0.8903	22.0	7.4	14.9	.....	65.0	50.0	36.0	32.5	52.0	40.0	.....	.....

in any definite relationship to one another (8). The duration of the growth period varied, so that it is not possible to note an effect of the season upon absorption (9).

In the sulphate series the Egyptian type of seedlings absorbed more of the sulphate than did the Upland type during the same growth period. The increased absorption here may be found to be related to the growth of the seedlings. The results suggest that the absorption of chloride and sulphate by the roots of plants may not bear the same relationship to one another in the different types of cotton seedlings as do the chloride and sulphate content of leaf tissue fluids. The absorption of ions by plants, as a basis for distinctions between different forms of cotton seedlings, requires considerable further study under controlled conditions.

CITRUS EXPERIMENT STATION
RIVERSIDE, CALIF.

[*Accepted for publication April 15, 1927*]

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BRIEFER ARTICLES

AN ABNORMAL INFLORESCENCE OF SYMPLOCARPUS FOETIDUS

(WITH ONE FIGURE)

One of the most interesting of swamp inhabiting plants is *Symplocarpus foetidus*, and therefore the observation of any novel characteristic in this species is sure to command attention. In April 1926, SAMUEL W. SMITH of Rootstown, Ohio, sent to the writer an inflorescence of *Symplocarpus* in which the spadix was enveloped by two spathes instead of one. In the ordinary development of all spadiceous plants, the inflorescence is provided with a single bract, and therefore this instance of departure from the normal behavior seemed worth recording.

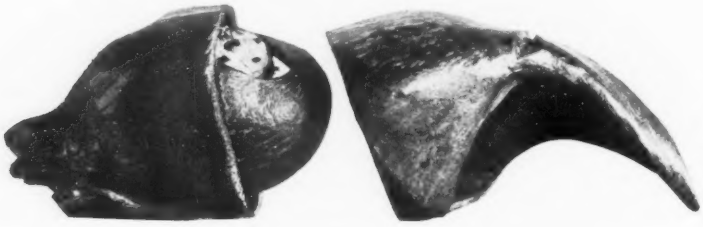

FIG. 1

Fig. 1 shows the orientation of the two spathes. SHULL[1] has shown that *Symplocarpus* in its early life passes through a period of monopodial development, which is succeeded by a sympodial stage. During the monopodial stage the leaves are all rolled in the same direction, but in the sympodial stage the direction of rolling is reversed for each successive leaf. It will be observed that the spathes in the illustration have this same reversed orientation. SHULL has also pointed out that the monopodial stage ends when the terminal bud gives rise to the first spathe. In the sympodial stage the succession shoot bears two leaves, and the upper axillary bud always becomes the new terminal. Concerning this freak

[1] SHULL, J. MARION, *Spathyema foetida*. BOT. GAZ. **79**:45–59. 1925.

specimen the question now arises as to the origin of the additional spathe. Does it represent the interpolation of a new primordial region, or rather the modification of a subtending leaf primordium? It would be very difficult to answer this question from the available evidence, but there is some indication that we have here the development of a second spathe primordium in the axillary bud, with the same orientation as that of the leaves.

The writer believes this to be the first *Symplocarpus* inflorescence of this kind ever recorded, for rather extensive inquiry has failed to reveal any reported observations of a similar development.—P. D. STRAUSBAUGH, *West Virginia University, Morgantown, W. Va.*

[*Accepted for publication March 4, 1927*]

CURRENT LITERATURE

BOOK REVIEWS

Plant autographs and their revelations

This little book is a popular presentation of BOSE'S[1] life-long investigations of plant response. The tenor of the presentation is forecast in the preface, where the author remarks concerning the plant that, "in order to reveal the intricate mechanism of its life, it is necessary to gain access to the smallest unit of life, the 'life atom,' and record its throbbing pulsation."

There are twenty-seven chapters and an appendix, which tell the story of sleeping, waking, irritable, nervous, and weeping plants. He recounts the use of his resonant recorder, sleep recorder, automatic recorder, high magnification crescograph, electric probe, electric phytograph, optical sphygmograph, etc., in measuring the otherwise invisible responses of plants under environmental and artificial stimulation. One must admire the genius of BOSE in the invention of delicate recorders of infinitesimal responses. Moreover, the facts of these responses are a challenge to all biologists who are interested in the properties of protoplasm. Everything is in need of explanation and interpretation, for no sane biologist will accept BOSE'S interpretation unless compelled to by critical and penetrating reinvestigation of the phenomena. Some of the former books, presenting more technically the results of his experiments and his reasoning from the observations, are unconvincing. The transpiration stream rise of sap by virtue of pulsating phloem vessels is a theory entirely untenable in the reviewer's opinion. Experiments in this laboratory using BOSE'S bubbler method have failed entirely to confirm his story of sap rise as told in his book dealing with transpiration. We have not been able to find any convincing evidence for a vitalistic interpretation of sap rise. On the other hand, there is no question that many of BOSE'S observations are correct; and correct interpretation of the phenomena, divested of all mysticism, is much needed.

Similarly, the chapters dealing with the so-called nervous phenomena in plants need reinterpretation, as there is no reason for drawing parallels between general protoplasmic conductivity and nerve action of animals. The unfortunate thing about such a book is that it is more enticing to lay readers than a truly scientific account of these same phenomena. If it should make no more impression upon these readers than BOSE'S scientific works have made upon scientists, little harm would be done; but it is more likely that much effort

[1] BOSE, J. C., Plant autographs and their revelations. 8vo. pp. xviii+240. New York: Macmillan Co. 1927.

will be required in attempts to eradicate misconceptions and misunderstandings of plant life from the minds of those whose first contacts with biology are made through such popular and inaccurate representations of life phenomena. As a contribution to the imaginative interpretation of plant life, it should be ranked high.—C. A. SHULL.

Myths and legends of flowers

For those interested in the mysterious, in fables and in legends, a recent volume[2] will furnish many hours of entertainment and amusement. Tales of all sorts connected with flowers and plants are told, many of them borrowed from classical mythology, others from the folklore of various lands. The plants discussed are as various as the sources of the tales. They range from the common wayside weeds such as the thistle and mustard, through the flowers of the garden and the forest such as the lily, the rose, and the violet, to the trees of the wood such as the oak and the cedar, to exotics like orchids and passion flower, and to the less familiar tropical trees like the sal (*Shorea robusta*) and the palms.

Perhaps it is too much to expect scientific accuracy in such a volume, but it does seem that scientific names should be correctly capitalized, and that the real identity of plants designated by common names only should be revealed.

Most of the tales are told in a pleasing manner, so that they may serve to brighten a quiet hour.—G. D. FULLER.

Root development

A new volume on root development of vegetable crops[3] has just appeared from the press, and it is in every way a companion text to WEAVER'S *Root development of field crops*, which was so well received last year. The introductory chapter deals in a somewhat general way with questions of plant physiology, ecology, and agricultural practices, pointing out the interrelations between plant and soil. Direct measurements are recorded and applications are made (Chapters II–XXXIV) to forty or more different vegetable plants. Stress generally is placed upon early growth, midsummer growth, mature plants, root habits in relation to cultural practice, soils and fertilizers, and transplanting.

The average reader is sure to be surprised at the extent of the unseen portion of vegetable plants. Without these measurements, who would believe that a horse-radish would send roots 15 feet deep, or that an 8 weeks old sweet-corn plant covers 7 feet with shallow lateral roots? Ninety-four diagrams and photographs are used to show extent and types of roots.

While some data of other publications are included, the book as a whole

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[2] SKINNER, M., Myths and legends of flowers, trees, fruits and plants. Philadelphia and London: J. B. Lippincott and Co. 5th impression. pp. ix+302. *pls.* 17. 1925. $3.00.

[3] WEAVER, J. E., and BRUNNER, W. E., Root development of vegetable crops. 8vo. pp. xiii+351. New York: McGraw-Hill Book Co. 1927.

represents the findings of the authors over several years of research, and since the book deals with problems of so much importance, it will be welcomed by investigators, students, and practical horticulturists.—P. W. ZIMMERMAN.

Check list of forest trees

One of the latest of many valuable contributions by SUDWORTH[4] is a check list of the forest trees of the United States. This volume contains far more than a complete list of names, useful as that would be. To a careful synonymy is added a list of the common names by which the particular trees are known, and also a list of the varieties distinguished in cultivation. In a group of plants like trees, when many an author is a law unto himself in matters of nomenclature, such a carefully annotated treatment of synonyms becomes of great importance. Other topics discussed include the range of each species, trade names for wood, names of hybrid and naturalized trees, and standard names for lumber recommended by the United States Forest Service.

Of the 1177 different tree species recognized, 182 are regarded as of special interest economically. The usefulness of this check list will be all the greater since it may be procured from the Superintendent of Documents, Washington, D.C., for the small price of 40 cents per copy.—G. D. FULLER.

NOTES FOR STUDENTS

Taxonomic notes.—PITTIER[5] has published an account of the Central American representatives of the Lecythidaceae, the brazil nut family. It is stated that "the group has been little studied, since they are mostly large trees, growing in wet virgin forests difficult of access, and it is hard to procure specimens of them." PITTIER describes 5 genera and 19 species, 11 of which are new.

RUSBY[6] has described 10 new species of *Munnozia* (Compositae), a genus which has usually been presented as a section of *Liabum*. The plants are usually erect shrubs, growing at high altitudes in the South American Andes.

In continuation of his presentation of the Fabaceae, RYDBERG[7] describes 31 species of *Hamosa*, additional to the 21 species described in the preceding paper, 8 of which are new. This genus is a segregate from *Astragalus*.

ROSE and STANDLEY[8] have published the species of *Hydrocotyle* from Central

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[4] SUDWORTH, G. B., Check list of the forest trees of the United States, their names and ranges. U.S. Dept. Agric. Misc. Circ. 92. pp. 295. 1927.

[5] PITTIER, H., The Lecythidaceae of Central America. Contrib. U. S. Nat. Herb. **26**: 1–14. 1927.

[6] RUSBY, H. H., Additions to the genus *Munnozia* R. & P. Bull. Torr. Bot. Club **54**: 311–320. 1927.

[7] RYDBERG, AXEL. Notes on Fabaceae. IX. Bull. Torr. Bot. Club **54**: 321–336. 1927.

[8] ROSE, J. N., and STANDLEY, PAUL C., The Central American species of *Hydrocotyle*. Jour. Wash. Acad. Sci. **17**: 194–199. 1927.

America, based on the abundant material secured by recent explorations. They recognize 8 species, 4 of which are described as new. Two of these new species are remarkably localized, being known only from a single limited locality.

HITCHCOCK[9] has published an account of all the grasses known from Ecuador, Peru, and Bolivia. In 1923 he visited those countries to study the grasses of the Central Andes. It was difficult to identify the specimens, because of the widely scattered descriptions and because the grasses of the region have never been brought together for publication. This paper, therefore, is the first attempt to coordinate all the known grasses of the region. As a result, 605 species are presented, 29 of which are new, included in 124 genera. The following 7 genera include almost one-half of the species: *Paspalum* (54 species), *Panicum* (52 species), *Calamagrostis* (43 species), *Eragrostis* (33 species), *Poa* (28 species), *Stipa* (26 species), and *Festuca* (21 species). There are 52 monotypic genera.

COKER and BRAXTON[10] have published the results of their recent studies of water molds from the soil in North Carolina. A number of new species are described, and also two new genera, *Brevilegnia* and *Calyptralegnia*.

COUCH[11] has published the results of his studies of the water molds collected from the soil around Cold Spring Harbor. Among them he describes two new species of *Brevilegnia*, a new genus recently described from material obtained in North Carolina.

HUTCHINSON and DALZIEL[12] have begun the publication of descriptions of tropical African plants. The first number includes descriptions of 18 new species in 4 families, as follows: Anonaceae 8 species, Lauraceae 1 species, Ranunculaceae 2 species, Menispermaceae 7 species. This work is in connection with the publication of a new flora of West Tropical Africa undertaken by the Royal Botanic Gardens.

In continuation of his work on the flora of Siam, GEDDES[13] has published 20 new species of Rubiaceae, 12 of which belong to the genus *Argostemma*.

SANDWITH[14] has published 14 new species from Argentina, obtained from the collection of H. F. COMBER upon a botanical expedition last year into the Andes of that country.

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[9] HITCHCOCK, A. S., The grasses of Ecuador, Peru, and Bolivia. Contrib. U.S. Nat. Herb. **24**: 291–556. 1927.

[10] COKER, W. C., and BRAXTON, H. H., New water molds from the soil. Jour. Elisha Mitchell Sci. Soc. **42**: 139–149. 1926.

COKER, W. C., Other water molds from the soil. *loc. cit.* **42**: 207–226. 1927.

[11] COUCH, J. N., Some new water fungi from the soil, with observations on spore formation. Jour. Elisha Mitchell Sci. Soc. **42**: 227–242. 1927.

[12] HUTCHINSON, J., and DALZIEL, J. M., Tropical African plants. I. Kew Bull. Miscell. Inf. 1927. no. 4. pp. 150–157.

[13] GEDDES, E. T., Contributions to the flora of Siam. Kew Bull. Miscell. Inf. 1927. no. 4. pp. 164–174.

[14] SANDWITH, N. Y., New species from the Andes of Argentina. Kew Bull. Miscell. Inf. 1927. no. 4. pp. 174–188.

BROWN[15] has described a new genus of Apocynaceae from tropical East Africa and Madagascar. The name *Lanugia* refers to the downy or velvety pubescent inner surface of the corolla lobes. It includes 3 species, 2 of which have been transferred from *Mascarenhasia*.

OGURA[16] has published the results of his studies of specimens of fossil stems and petioles obtained from Mesozoic deposits in Japan. Three new genera are described, namely, *Cyathocaulis*, *Cibotiocaulis*, and *Cyathorachis*. The descriptions are very detailed and well illustrated. The author concludes that these genera are related to the Cyatheaceae. The exact systematic position could not be determined because of the lack of fronds.

KILLIP,[17] in preparing a revision of American Passifloraceae, has discovered some new species which he publishes in advance of the publication of the completed revision. Twelve species of *Passiflora* are described, 2 from Mexico, 1 from Cuba, and the remaining 9 from various countries of South America.

Miss KANOUSE[18] has begun the publication of her investigations of certain groups of water molds concerning which there has been very incomplete information. In the present paper 23 species of Blastocladiaceae are presented, the experimental work and the morphological results being fully described. A new order, Leptomitales, is established; also a new genus, *Mindeniella*, 3 new species of *Blastocladia*, and 1 new species of *Allomyces*. Twelve of the species included in this monograph were collected in the vicinity of Ann Arbor, Michigan.

DANDY,[19] in connection with his investigation of Magnoliaceae, has described 4 new genera from Asia, namely, *Alcimandra*, *Pachylarnax*, *Elmerrillia* (including 5 species segregated from other genera), and *Kmeria*. In addition, he publishes 10 new names and combinations. His conclusion is that "much of the confusion which for a long time has existed in this group is due to the various interpretations of the limits of the genera."

TRELEASE[20] has published 13 new species of *Phoradendron*, an exclusively American genus, which have come to his attention since the publication of his monograph. The majority of the species are from Ecuador, Venezuela, and Colombia.

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[15] BROWN, N. E., *Lanugia*, a new genus of rubber-yielding trees. Torreya **27**: 51–53. 1927.

[16] OGURA, YUDZURU, On the structure and affinities of some fossil tree ferns from Japan. Jour. Imp. Univ. Tokyo. Section III. Botany. **1**:351–380. *pls. 2–8*. 1927.

[17] KILLIP, E. P., New passion flowers from South America and Mexico. Jour. Wash. Acad. Sci. **17**:423–431. 1927.

[18] KANOUSE, BESSIE B., A monographic study of special groups of the water molds. I. Blastocladiaceae. Amer. Jour. Bot. **14**:287–306. 1927.

[19] DANDY, J. E., The genera of Magnolieae. Kew Bull. no. 7. pp. 257–264. 1927.

[20] TRELEASE, W., Additions to the genus *Phorandendron*. Bull. Torr. Bot. Club **54**:471–477. 1927.

BLAKE[21] has described an endemic group of species of *Aplopappus* occurring in the Andes of northwestern South America. Formerly this group had been regarded by BENTHAM and HOOKER as a section of *Chrysothamnus*, and by GRAY as a section of *Bigelovia*. BLAKE has now transferred it to *Aplopappus*, describing 9 species, 5 of which are new.

STEVENS[22] has described 3 new genera of tropical fungi. *Shropshiria* is from Panama, and its relationship is said to be problematic. For the present it should probably be included among the Fungi Imperfecti, but it shows no relationship to the 3 orders of that assemblage. *Clypeodiplodina* is from Ecuador, and probably belongs to the Pycnidiaceae. *Chaetothyriopsis* is from Panama. It is an invisible fungus except with the aid of a compound microscope.

PAINE[23] has been investigating the fungi of virgin soils, since the greater amount of work has been done with cultivated soils in the interest of agriculture. The fungi were isolated from pasture land and timber land near Iowa City, Iowa. The investigation resulted in the discovery of 30 species, 5 of which are described as new. "There was a marked diminution in the frequency of occurrence of fungi with increase in depth beyond the first 3 inches, but the lower depths yield their proportion of the new species, 4 of the 5 new forms found being isolated from 6 to 12 inches below the surface."

GARDNER[24] has published descriptions of 11 new species of *Gelidium* discovered along the coast of California. These seaweeds grow chiefly in the sublittoral belt, although some of them occur in deeper water. The descriptions are accompanied by 19 exceptionally good plates.

TRELEASE[25] has published a revision of the Piperaceae known to occur in Panama. The family is remarkably well represented in that region. Doubtless many more species will be found, since no part of Panama has been explored for such material except the region of the Canal Zone. The present revision includes 139 species, *Piper* containing 92, and *Peperomia* 44. A new genus, *Sarcorhachis*, is described, based upon a species formerly included in *Piper;* 42 new species are described in *Piper*, and 19 in *Peperomia*.—J. M. C.

Alpine vegetation related to alpine soils.—The advantages of associating with an ecologist a collaborator trained in soil science, is seen in a recent

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[21] BLAKE, S. F., The section Diplostephioides of *Aplopappus*. Amer. Jour. Bot. **14**:107–115. 1927.

[22] STEVENS, F. L., New tropical fungi. Mycologia **19**:231–238. 1927.

[23] PAINE, F. S., Studies of the fungous flora of virgin soils. Mycologia **19**:248–367. 1927.

[24] GARDNER, N. L., New species of *Gelidium* on the Pacific coast of North America. Univ. Calif. Publ. Bot. **13**:273–318. 1927.

[25] TRELEASE, W., The Piperaceae of Panama. Contrib. U.S. Nat. Herb. **26**:15–50. 1927.

investigation of the vegetation of Central Switzerland by BRAUN-BLANQUET,[26] who has been assisted in his interpretation of soil phenomena by HANS JENNY. In the humid conditions of the alpine climate soil development tends to proceed from basic or weakly acid conditions to a strongly acid climax, and this evolution is irreversible. It is demonstrated that correlated with these changes in soil conditions there is a definite plant succession leading to a definite climax vegetation. In many parts of the Alps the climax association is one characterized by *Carex curvula*. This oxalophytic association agrees in its distribution with areas occupied by the strongly acid climax soil, the alpine humus soil. In regions of siliceous rocks these climaxes of soil and vegetation are of common occurrence, but upon substrata of limestone the soil changes are so slow and gradual that the climax stages are only occasionally found upon gentle slopes and flat-topped ridges.

The calcicolous species are usually the pioneers, and represent plants of great constructive value in the development of the association. Presently, however, the acid tolerant and acid demanding species come into competition with species having basic soil preferences, and with the development of the soil climax the former become more abundant. Thus as the plant succession develops, the range of toleration for pH soil values is narrowed and limited to those of rather high acidity.

Among the phases of the subject investigated in a quantitative manner are the great importance of wind-blown material and the ratio between humus production and humus destruction. The development of alpine soils is shown to be from the "braunerde" or "rendzina" stage, through the podsol stage to the climax of the alpine humus soil.—G. D. FULLER.

Desert vegetation illustrated.—The strikingly characteristic plants of the Arabian and Egyptian deserts are brought graphically before us by STOCKER,[27] in a recent issue of the *Vegetationsbilder*. The score of plates maintain the high character of excellence peculiar to this publication. They include several good landscapes, and also habit studies of species of *Zygophyllum, Erodium, Cotula, Capparis, Statice*, and *Zilla*.—G. D. FULLER.

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[26] BRAUN-BLANQUET, J. (with JENNY, HANS), Vegetations-entwicklung und Bodenbildung in der alpine Stufe der Zentralalpen (Klimaxgebiet des Caricion curvulae). Denkschr. Schweiz. Naturf. Gesell. **63**:175–349. 1926.

[27] STOCKER, OTTO, Die Agyptesch-Arabische Wuste. Vegetationsbilder, KARSTEN & SCHENCK **17**: heft 5–6. *pls. 25–36*. 1927.

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